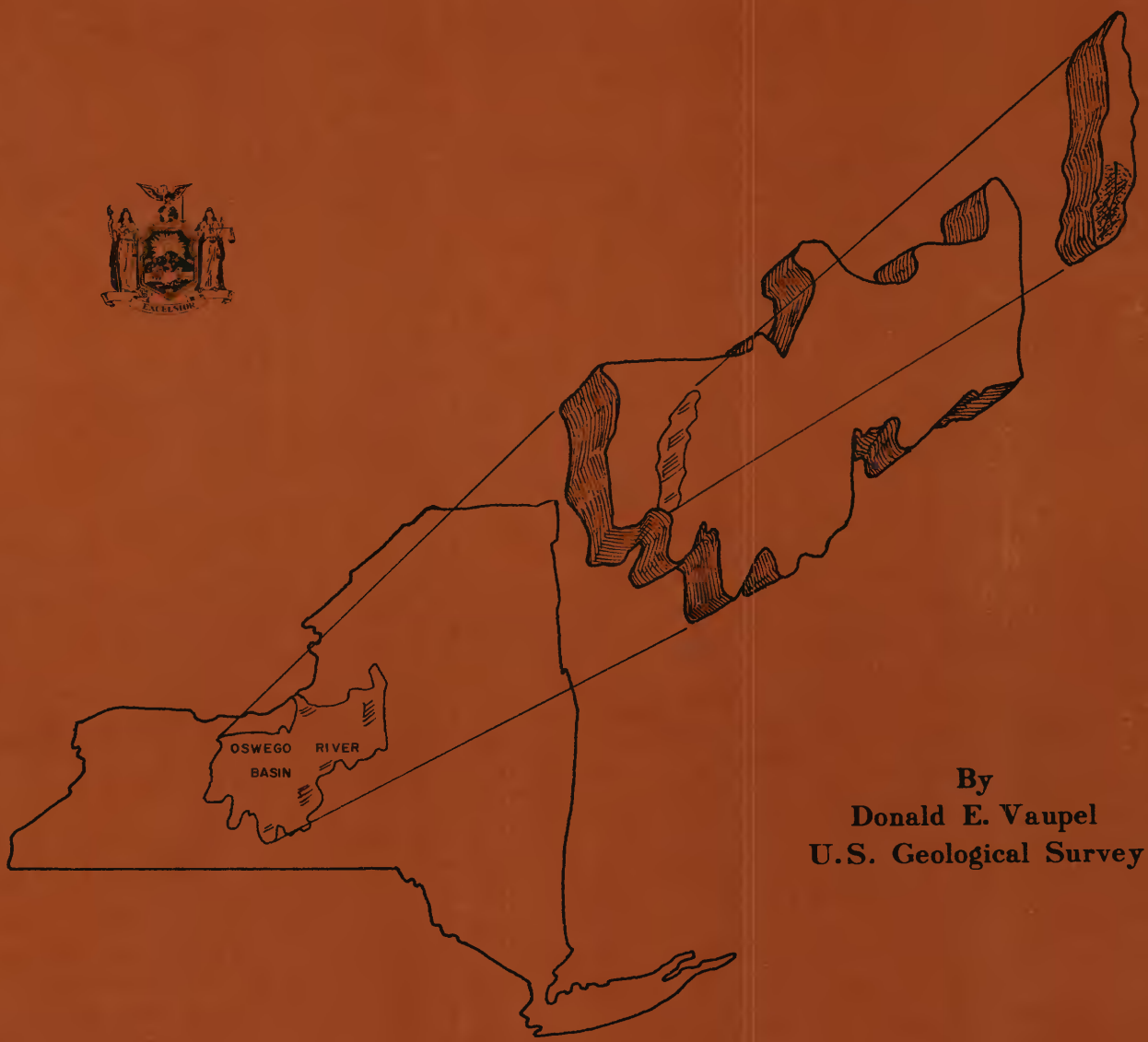
SURFACE-WATER REGIMEN OF THE UPPER FLINT CREEK BASIN, NEW YORK

SURFACE-WATER REGIMEN OF THE UPPER FLINT CREEK BASIN—New York Water Resources Commission Bulletin 59



By
Donald E. Vaupel
U.S. Geological Survey

STATE OF NEW YORK
CONSERVATION DEPARTMENT
WATER RESOURCES COMMISSION

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UNITED STATES DEPARTMENT OF THE INTERIOR
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ABSTRACT

Flint Creek basin is located between Seneca and Canandaigua Lakes in the famed Finger Lakes region of central New York State. Upstream from Potter, New York, the basin has a length of 15 miles and an average width of approximately 2 miles, encompassing a drainage area of 31 square miles.

Mean annual precipitation in the upper part of the basin, above Potter, is 35 inches. Because of evapotranspiration losses only about 30 percent of this leaves the basin as streamflow.

The average annual discharge of Flint Creek at Potter is approximately 18,500 acre-feet per year (25.5 cubic feet per second). At average intervals of 30 years, a yearly mean discharge of 10,000 acre-feet per year or less, and 30,000 acre-feet per year or more, can be expected. During an average year between 45 and 55 percent of the total annual flow occurs during the months of March and April. If a 30-year recurrence interval is considered, a storage of about 14,500 acre-feet is needed at Potter to supply a constant annual draft of 15,000 acre-feet for downstream uses. If a reservoir at Potter has 5,000 acre-feet of flood storage, an outflow of more than 200 cubic feet per second is expected once every thirty years.

INTRODUCTION

PURPOSE

The U.S. Department of Agriculture has applied to the New York State Water Resources Commission for a permit to construct a reservoir in the upper part of the Flint Creek basin near Potter, Yates County, for the purposes of irrigation, low-flow augmentation, industrial water supply, flood control, and recreation. The U.S. Geological Survey was asked by the State to study the hydrology of the upper part of the basin as it might apply to determination of the hydrologic feasibility of the proposed reservoir. This report describes the investigation that was undertaken and the results derived from it.

FIELD AND OFFICE TECHNIQUES

Most of the field data were collected during the period March 1, 1964, to March 31, 1965. The field work included: (1) measurement of streamflow at 16 sites, (2) operation of water-stage recorders at 4 sites, (3) construction and logging of 7 test holes, (4) collection of records at 9 wells, and (5) mapping the surficial geology of the upper basin.

Office work consisted mainly of extension and analysis of the field records that were collected. The analysis included determination of: (1) mean annual discharge, (2) variations in annual mean discharge, (3) monthly variations of streamflow, (4) areal distribution of streamflow, (5) effect of evapotranspiration losses on streamflow, (6) draft-storage relationships, and (7) flood-detention relationships.

ACKNOWLEDGMENTS

Field work was completed under the supervision of Donald F. Dougherty, formerly district engineer for U.S. Geological Survey surface-water investigations in New York. Report preparation was supervised by Ralph C. Heath, district chief for the Geological Survey's Water Resources Division in New York. Other Geological Survey colleagues who assisted the author include J. A. Robideau, who planned and carried out a major portion of the field work, and Messrs. G. A. Kirkpatrick and C. H. Hardison, who suggested statistical (analytical) techniques that improved the quality of the report. The study was made under provisions of a cooperative agreement with the Division of Water Resources, New York State Conservation Department.

THE BASIN

LOCATION AND CULTURE

Flint Creek is located in the famed Finger Lakes region of central New York State and is tributary to Canandaigua Lake Outlet. Figure 1 shows the Flint Creek basin and its relationship to the cities, villages, and prominent drainage features of the region. This report is concerned with the area, shown lined in figure 1, that encompasses 40 square miles in Yates and Steuben Counties.

The region is rural; only the small unincorporated villages of Italy, Potter, and Friend are located in the area of study. Farming is the principal occupation. Many of the dwellings in the area are used as summer homes.

PHYSICAL SETTING

The valley occupied by Flint Creek upstream from Potter is similar in many respects to the valleys occupied by the Finger Lakes, including Canandaigua Lake to the west and Seneca Lake to the east. The floor of the valley upstream from Potter, except for the headwaters portion, is about half a mile wide and is remarkably flat. It is bordered on either side by parallel ridges with steep slopes which extend upward to a relatively undissected upland. The valley, thus, gives the appearance of a flat-bottomed, relatively steep-sided gorge that has been cut into a gently rolling upland.

The headwaters of Flint Creek are in an irregular hilly region in the northern part of Steuben County at an altitude of about 2,000 feet above mean sea level. The creek flows for about 3 miles through a V-shaped irregular valley, which descends to an altitude of about 1,250 feet before it enters the main valley described above.

Most of the tributaries of Flint Creek consist of short steep-gradient intermittent streams that drain the slopes bordering the valley. The principal exceptions are the creeks draining Segar Gully, which also drains the irregular area at the upper end of the basin, and Nettle Valley Creek, which drains about 7 square miles of the basin located southeast of Potter. (See figure 4.)

GEOLOGIC SETTING

The rocks underlying the upper basin can be divided into two major categories: (1) consolidated rocks, and (2) unconsolidated deposits. Because this study is concerned with the occurrence and movement of water,

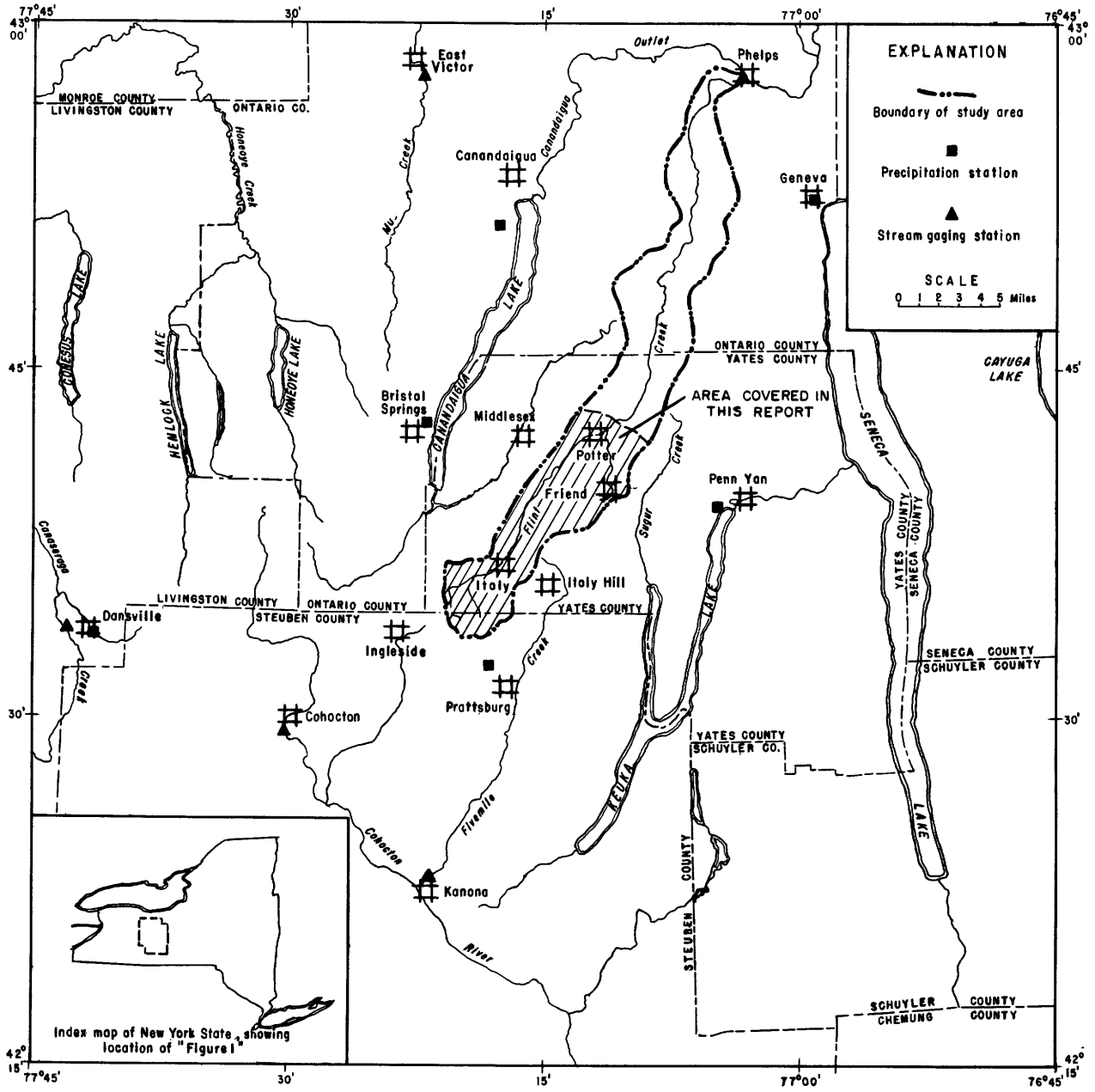

Figure 1.--Map of the Flint Creek basin and the surrounding region showing precipitation and stream-gaging stations used in this study that are outside of the study area.

the rock units will be described in terms of permeability, which is the capability of a material for transmitting a fluid.

BEDROCK GEOLOGY

The entire part of Flint Creek basin above Potter is underlain by consolidated rocks consisting of interbedded sandstone, siltstone, and shale of Upper Devonian age (Fisher and others, 1962). These rocks are essentially flat-lying, but have a regional dip of about 30 feet per mile in a southerly direction. These rocks have a relatively low permeability and, undoubtedly, they form a "foundation" under the valley through which very little water enters or leaves the area of investigation.

SURFICIAL GEOLOGY

Unconsolidated deposits cover the bedrock of the upper Flint Creek basin to varying depths. These deposits, which were formed during or shortly after the ice ages that occurred more than 15,000 years ago, vary considerably in areal extent, thickness, composition, and permeability. The thickness and relative position of these deposits were determined at seven points near the proposed reservoir site by drilling test holes with a power auger. Additional data of this type throughout the remainder of the upper basin were obtained from records of existing water wells. Logs of the 7 test holes and of 5 water wells are shown graphically in figure 2. The locations of the test holes and wells are shown in figure 3, and records of the wells are summarized in table 3.

Figure 3, which depicts the areal distribution of the unconsolidated deposits as determined by generalized mapping of the surficial materials, shows that most of the area is covered by an unsorted glacial deposit called till. This deposit has a varying thickness but a uniformly low permeability.

The next most extensive unconsolidated unit consists of deposits that were laid down in contact with or close to the ice sheet that once covered the area. Deposits of this nature, which are known as ice-contact deposits, are at both the north and south ends of the area. The thickness of these deposits is not known but probably exceeds 200 feet in places. Parts of these deposits have a relatively high permeability.

Most of the valley floor is covered with silt and clay which were deposited at the bottom of a glacial lake formed between the ice front to the north and the ice-contact deposits at the southern end of the valley. The lake deposits range in thickness from zero at the southern end of the valley to about 100 feet at Potter, and are relatively impermeable. Where tributary streams enter the main valley, deltas composed of sand and sand and gravel interfinger with and overlie the lacustrine silt and clay. These delta deposits have a relatively high permeability. Coarse-grained alluvial deposits, which are as much as 25 feet thick at Italy, overlie the lacustrine silt and clay at the southern end of the valley.

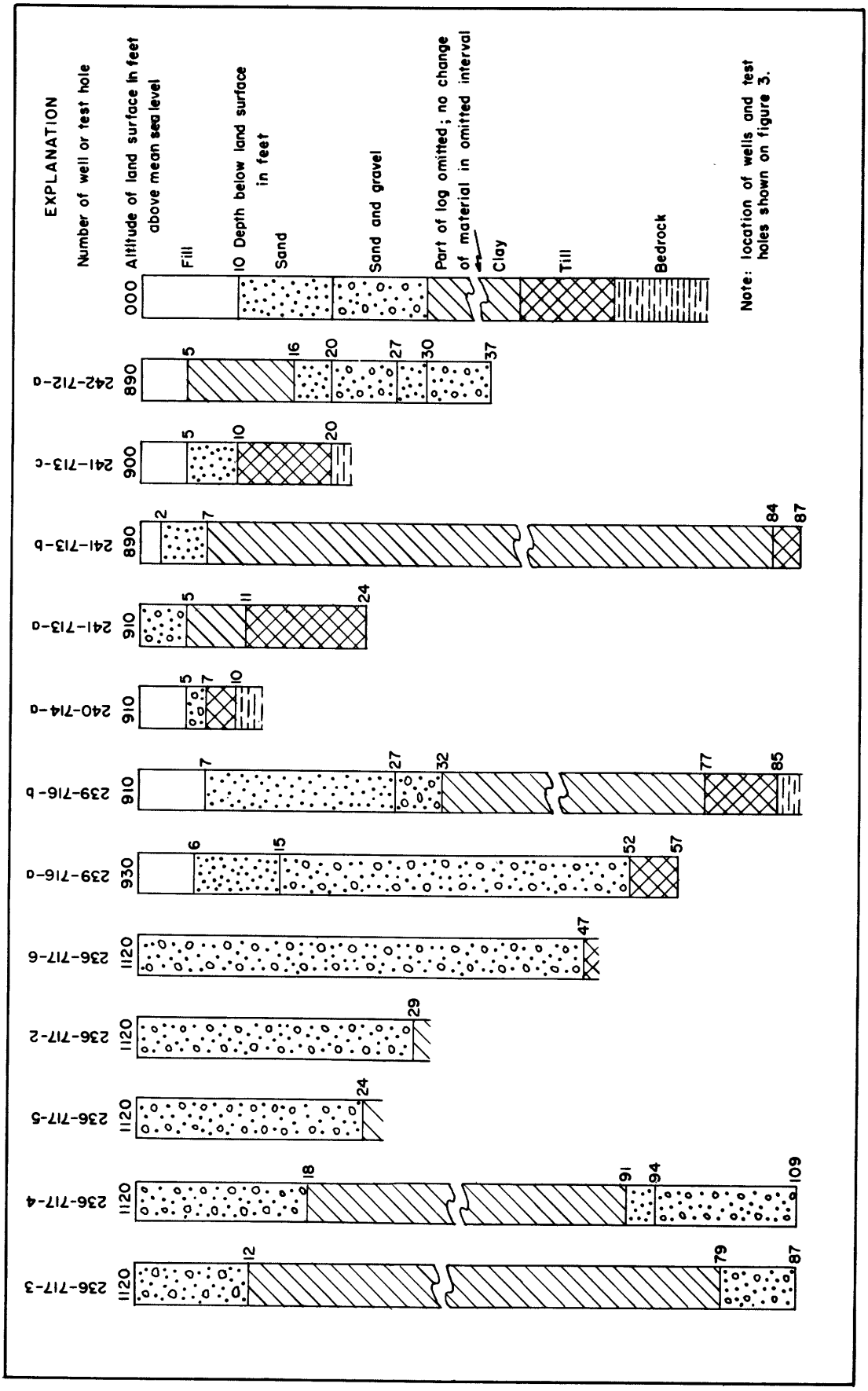

Figure 2.--Graphical logs of test holes and wells.

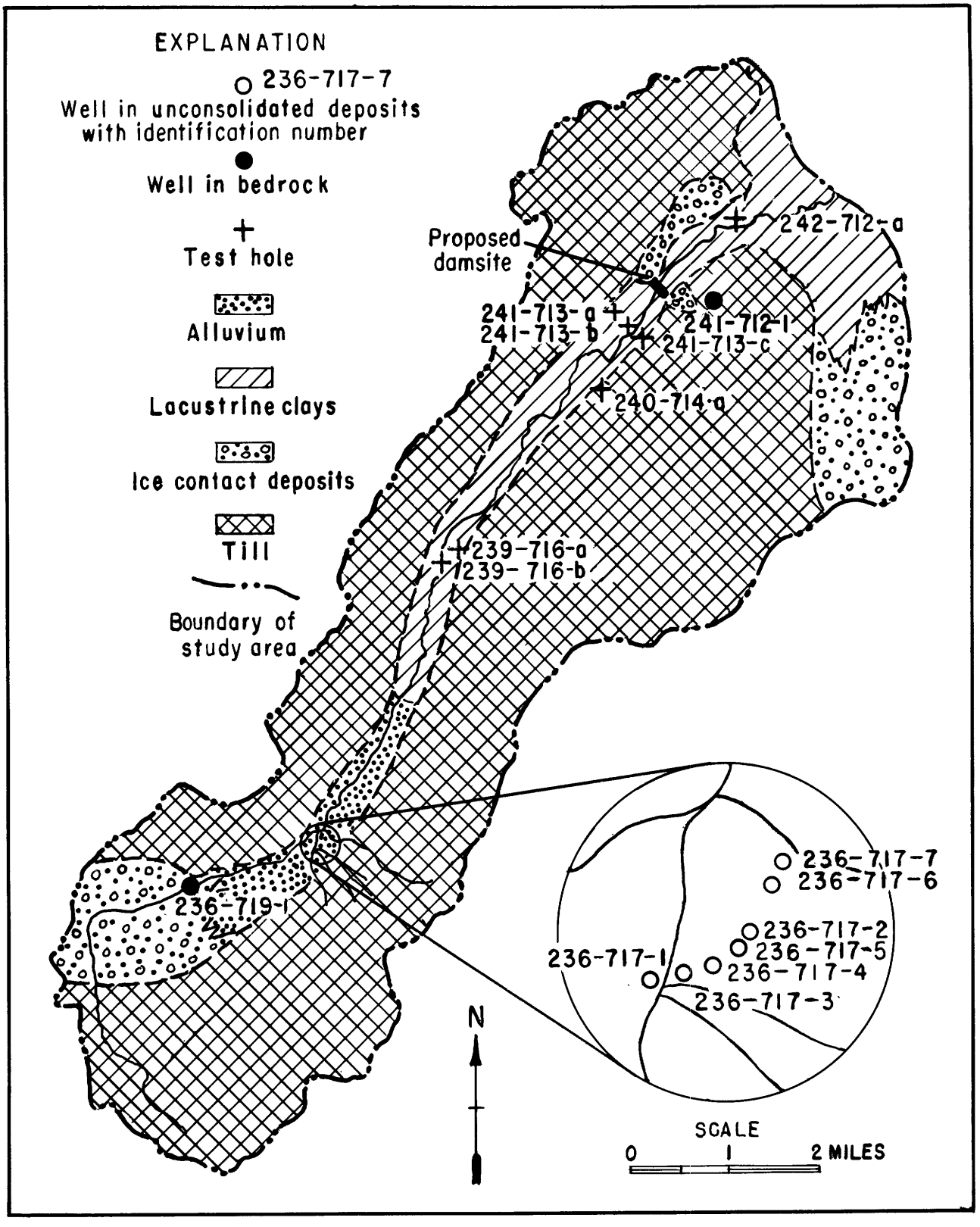

Figure 3.--Surficial geology and the location of selected test holes and wells.

HYDROLOGY OF THE BASIN

HYDROLOGIC CYCLE

The hydrology of the upper Flint Creek basin, as of any basin, is best discussed in terms of the hydrologic cycle. The hydrologic cycle comprises the series of events through which water passes from water vapor in the atmosphere to precipitation, to runoff on the land surface and infiltration into the ground, and finally back into the atmosphere again by means of evaporation from land and water surfaces and transpiration by vegetation. Mathematically, this was stated by Todd (1959) as:

Surface inflow + Subsurface inflow + Precipitation + Imported water + Decrease in surface storage + Decrease in ground-water storage

equal

Surface outflow + Subsurface outflow + Consumptive use + Exported water + Increase in surface storage + Increase in ground-water storage. (1)

In the upper Flint Creek basin parts of equation (1) can be readily eliminated. There is no surface inflow from adjoining basins; also, if the ground-water divide is assumed to coincide with the surface divide, there is no ground-water inflow. No water is known to be either imported to or exported from the basin. Although in certain years both the surface storage and subsurface storage, including the suspended water in the zone of aeration, may change considerably, over a long period of years the net change is very small and can be ignored.

On the basis of the above, equation (1) can be rewritten as:

$$\text{Precipitation} = \text{Surface outflow} + \text{Subsurface outflow} + \text{Consumptive use.} \quad (2)$$

Rewriting equation 2 into the form:

$$\text{Surface outflow} = \text{Precipitation} - (\text{Subsurface outflow} + \text{Consumptive use}), \quad (3)$$

it is seen that the streamflow in a basin is continually changing in response to changes in amount of precipitation, evapotranspiration losses (consumptive use), and ground-water discharge. Of these, variations in precipitation and evapotranspiration are most significant. Because the pattern and the amount of precipitation vary from year to year, the quantity of water flowing out of the area and the distribution of this flow with time also vary from year to year. Thus, an effective study of the hydrology of

such an area requires either the measurement of the streamflow at selected sites for an extended period of years or, if that is not possible, an extension of the available record by correlation with nearby long-term stations. It was necessary to follow the latter course in the Flint Creek basin.

COLLECTION AND EXTENSION OF RECORDS

The most important element in the study of the hydrology of the upper Flint Creek basin is the flow of the creek and its tributaries. Therefore, most of the field work was related to the collection of data on streamflow at 16 sites. The locations of these 16 sites are shown in figure 4. The primary control station in this network is the one at Potter (sta. 11), which was equipped with a continuous water-stage recorder and has been operated continuously since March 1, 1964. Three other stations, 4, 6, and 16, were equipped with water-stage recorders for short periods during the summer of 1964. At all stations, including those mentioned above, periodic discharge measurements were made with either current meters or flumes. These discharge measurements were made under base-flow conditions whenever possible -- that is, when all, or nearly all, of the flow in a stream was composed of ground-water discharge -- because the standard correlation procedures used in this study are more reliable when the streamflow data are obtained under these conditions. Table 4 gives pertinent data for all stream-gaging stations operated in the area. Tables 5 and 6, respectively, list all discharge measurements made, and all daily discharges computed for this study.

Long-term stream-gaging stations which geographically surround the upper Flint Creek basin, and which have streamflow patterns similar to Flint Creek at Potter, as shown in figure 5, are: Flint Creek at Phelps (records available 1959-64), Mud Creek at East Victor (1958-64), Canaseraga Creek near Dansville (1920-64), Cohocton River at Cohocton (1950-64), and Fivemile Creek near Kanona (1937-64). Records from these stations were correlated with the record obtained at Potter in 1964 using a method described by Oliver P. Hunt, U.S. Geological Survey (oral communications, 1965). Through this correlation, a flow-duration curve was developed for the station at Potter for the period 1931-60. This period is referred to in discussions of surface-water data as the "base period" and is the standard period used in many streamflow analyses. Using the 1931-60 curve developed for Flint Creek at Potter and a technique developed by Searcy (1959), flow-duration curves were developed for the other short-term stations operated in the Flint Creek basin. The flow-duration curve for Flint Creek at Potter for the base period is shown in figure 6. The equivalent curves for the other streams are shown in figure 7. It should be noted on the latter curves that the extension upward from 20 percent is based on a small number of discharge measurements and must, therefore, be used with caution.

A flow-duration curve is one of several graphical representations of streamflow. It shows, for the range of historical or expected flows past the measuring station, the percentage of time that each flow rate may be expected to occur or to be exceeded at that site. As an example, it can

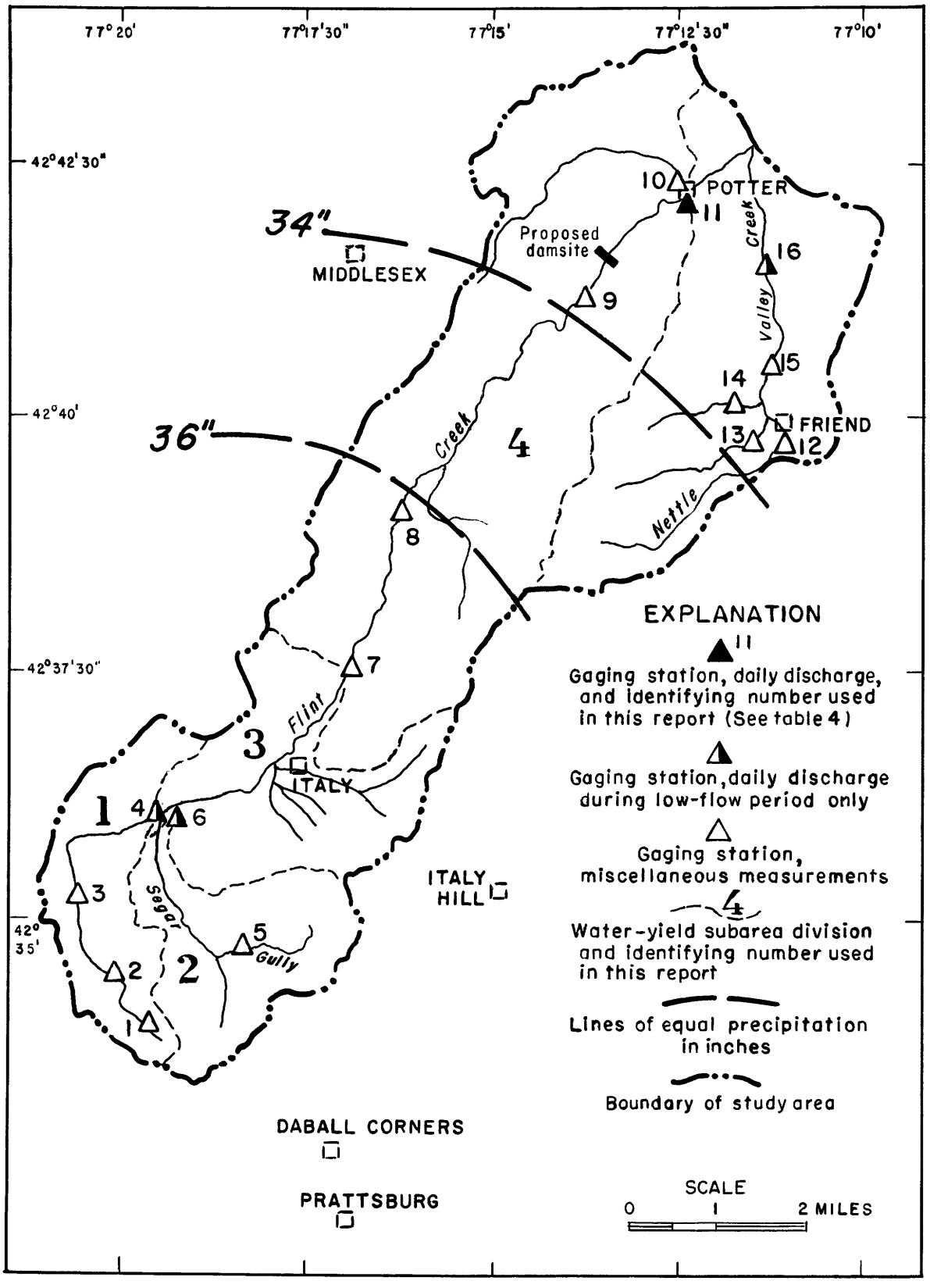

Figure 4.--Location of stream-gaging stations, lines of equal precipitation, and water-yield subareas.

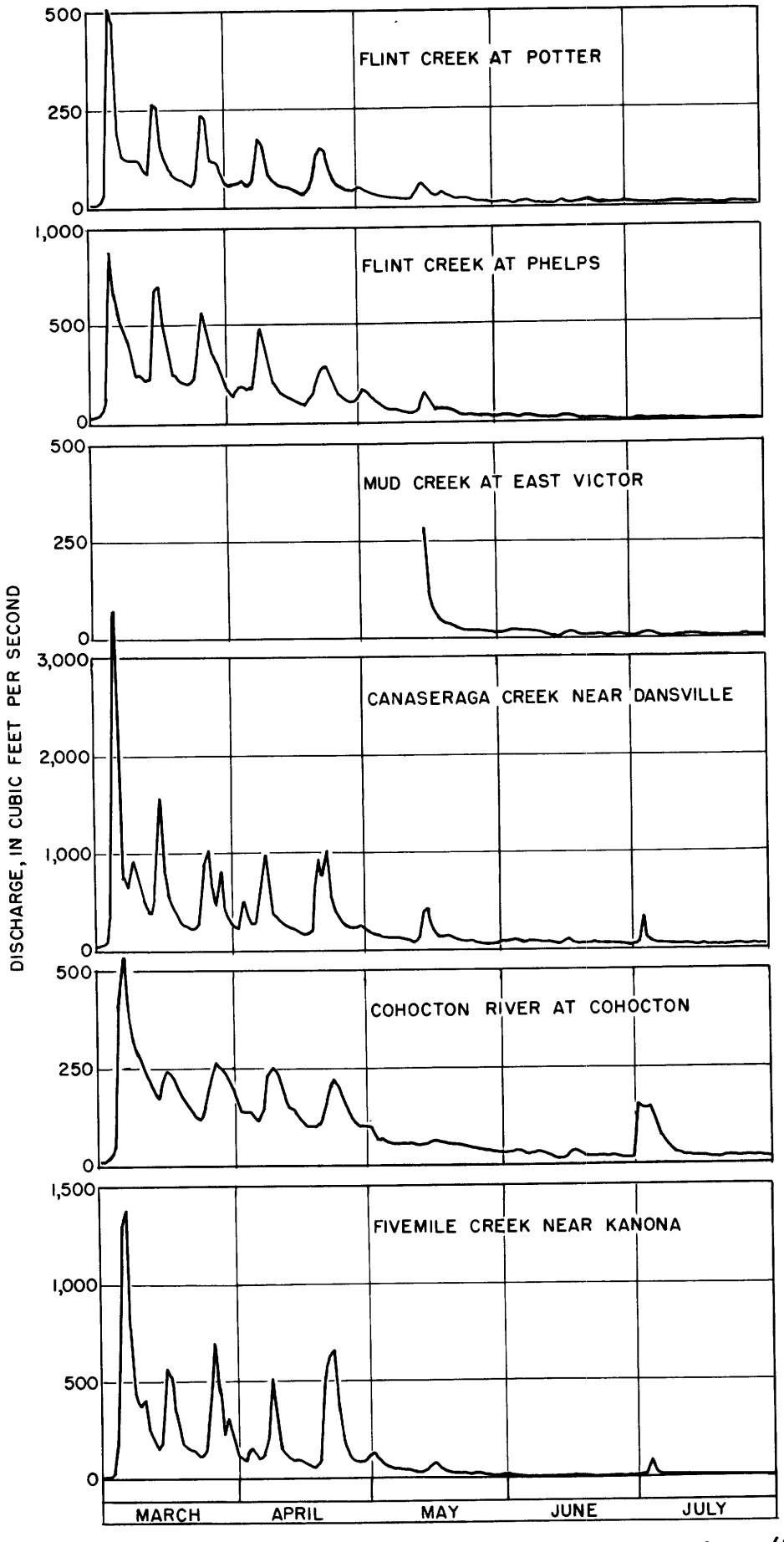

Figure 5.--Daily discharge of selected stream-gaging stations (March-July 1964) in and near the upper Flint Creek basin.

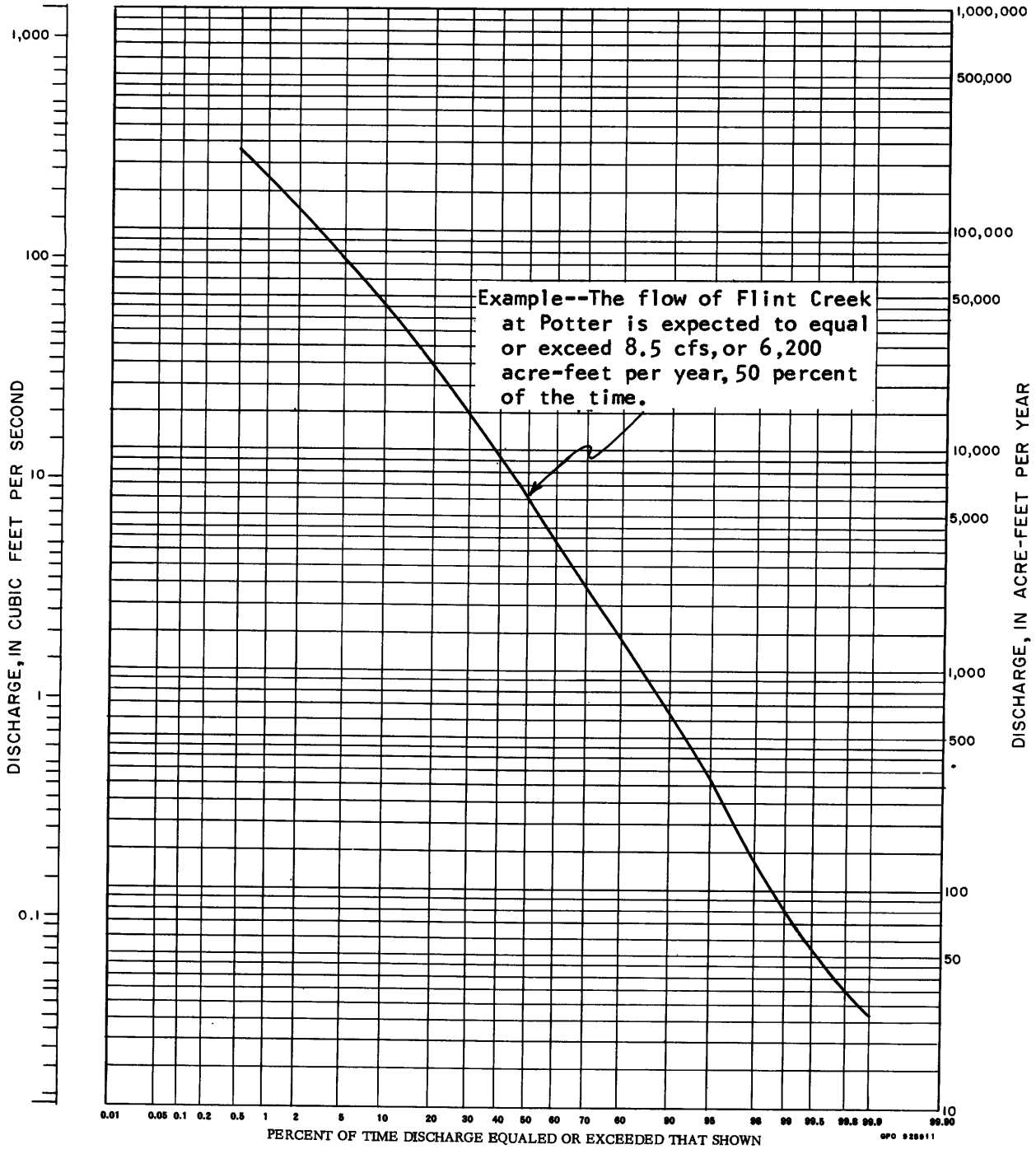
Example--The flow of Flint Creek at Potter is expected to equal or exceed 8.5 cfs, or 6,200 acre-feet per year, 50 percent of the time.
DISCHARGE, IN CUBIC FEET PER SECOND
DISCHARGE, IN ACRE-FEET PER YEAR
1,000
100
10
1
0.1
1,000,000
500,000
100,000
50,000
10,000
5,000
1,000
500
100
50
10
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.5 99.8 99.9 99.99
PERCENT OF TIME DISCHARGE EQUALED OR EXCEEDED THAT SHOWN

Figure 6.--Duration curve of daily flow, Flint Creek at Potter (sta. 11), 1931-60.

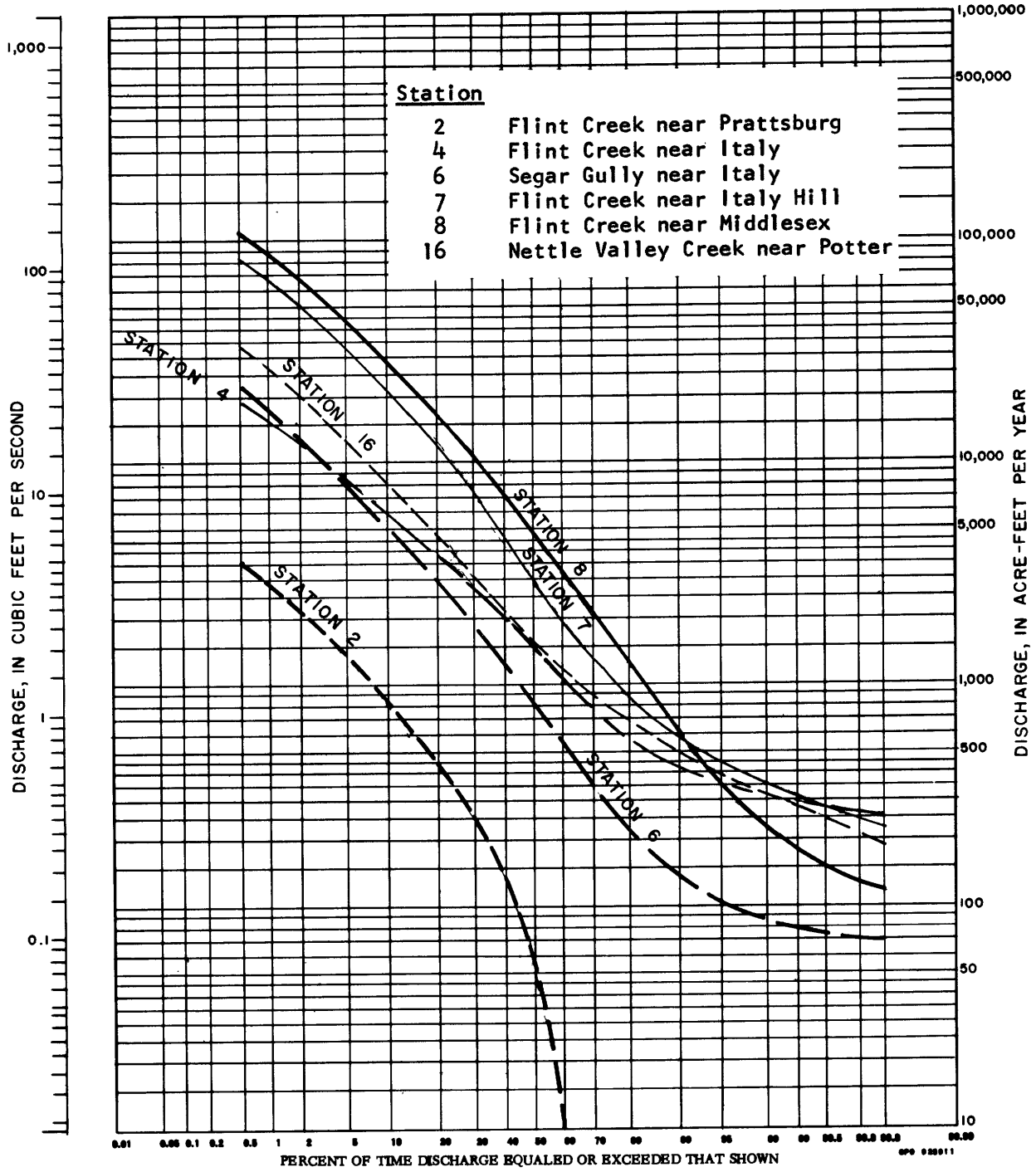
Station
2 Flint Creek near Prattsburg
4 Flint Creek near Italy
6 Segar Gully near Italy
7 Flint Creek near Italy Hill
8 Flint Creek near Middlesex
16 Nettle Valley Creek near Potter
STATION 4
STATION 16
STATION 8
STATION 7
STATION 2
STATION 6
DISCHARGE, IN CUBIC FEET PER SECOND
DISCHARGE, IN ACRE-FEET PER YEAR
PERCENT OF TIME DISCHARGE EQUALED OR EXCEEDED THAT SHOWN

Figure 7.--Duration curves of daily flow at stream-gaging stations 2, 4, 6, 7, 8, and 16, 1931-60.

be seen in figure 6 that the flow of Flint Creek at Potter is expected to equal or to exceed 8.5 cfs (cubic feet per second), or 6,200 acre-feet per year, 50 percent of the time. In other words, during half of the days in any year the flow at Potter can be expected to equal or exceed 8.5 cfs. These days may occur during any part of the year and may or may not occur consecutively. Because the range and magnitude of flows vary from year to year in response to variations in precipitation, the flow data used in compiling the flow-duration curve are averaged for a suitable base period -- in this case, the 30-year period 1931-60.

The flow-duration curves for the upper Flint Creek basin were used in several different parts of the data analysis, including the analysis of mean annual discharge and the study of the areal variation in streamflow.

It should be noted that any information obtained from the flow-duration curves developed by correlation for the upper Flint Creek basin is subject to an error caused by the short period of record that was available. However, it is probable that the error does not exceed plus or minus 10 percent.

DETERMINATION OF MEAN ANNUAL DISCHARGE

The mean annual discharge at any stream-gaging station allows calculation of the average volume of water that flows past that station each year, and is, therefore, one of the principal items that must be considered in the design of a storage reservoir. The mean annual discharge for Flint Creek at Potter (sta. 11), was determined by a method described by Mitchell (1957, p. 18-22). This method involves step integration of the area under the flow-duration curve to determine the mean annual discharge. Applying this method to the 1931-60 flow-duration curve for the Potter station, shown in figure 6, an average annual discharge of about 25.5 cfs or 18,500 acre-feet per year was obtained. Using a limit of error of plus or minus 10 percent, as stated above, a mean annual discharge ranging from 23 to 28 cfs or 16,700 to 20,300 acre-feet per year is obtained.

VARIATION OF ANNUAL MEAN DISCHARGE

The total runoff at any point on a stream may vary appreciably from year to year primarily because of variations in climatic factors. In order to appraise the capability of a stream to sustain a water development, it is desirable to determine the range of these variations. Of course, it is not possible to predict the year of occurrence of unusually high or low flows, or to predict whether such extremes will occur during consecutive years. However, by statistical analysis of the annual mean discharges at gaging stations having long periods of record, an estimate can be made of the probable recurrence intervals of future annual discharges. Gaging-station records for the long-term station on Fivemile Creek near Kanona (fig. 1) were used in such an analysis for the upper Flint Creek basin.

The method consisted of constructing a graph relating discharge at Fivemile Creek to that of Flint Creek, and using that graph to estimate the expected average annual discharges for certain recurrence intervals at the Potter station on Flint Creek as shown in table 1. This analysis suggests, for example, that once in 20 years the total annual runoff at Potter might be as low as 11,000 acre-feet, or as high as 28,000 acre-feet.

Table 1.--Frequency of annual mean discharge, Flint Creek at Potter

Recurrence interval (years)	During 1 year in the recurrence interval, an annual mean flow this low or lower is expected (acre-feet per year)	During 1 year in the recurrence interval, an annual mean flow this high or higher is expected (acre-feet per year)
5	14,000	22,500
10	12,000	25,500
15	11,500	27,000
20	11,000	28,000
25	10,500	29,000
30	10,000	30,000

MONTHLY VARIATIONS OF STREAMFLOW

The discharge of Flint Creek also varies from month to month; as in the case in most of the humid east, this variation is brought on mainly by seasonal climatic changes. Monthly distribution of streamflow at Potter was determined by comparing the streamflow record obtained at that station with records for two nearby long-term stations (Canaseraga Creek near Dansville, and Fivemile Creek near Kanona) and the 1960-64 record of Flint Creek at Phelps. The flow of the two long-term stations and Flint Creek at Phelps is shown graphically in figure 8 as percentage of total annual flow contributed each month. Because the streamflow patterns at these stations are similar to those of Flint Creek at Potter (fig. 5), one can predict that, in an average year, between 45 and 55 percent of the discharge of Flint Creek will occur during March and April. Also, in an average year more than 90 percent of the total annual discharge occurs between December and the following June. However, as is shown in figure 9 with the 1960 and 1961 records of Flint Creek at Phelps, discharge during individual years may vary considerably from the average.

AREAL DISTRIBUTION OF STREAMFLOW

In addition to the variation of streamflow with time, flow at any given instant differs from place to place throughout the basin. The areal variation of flow is caused by the diversity of the water-producing characteristics in different parts of the basin. This diversity is

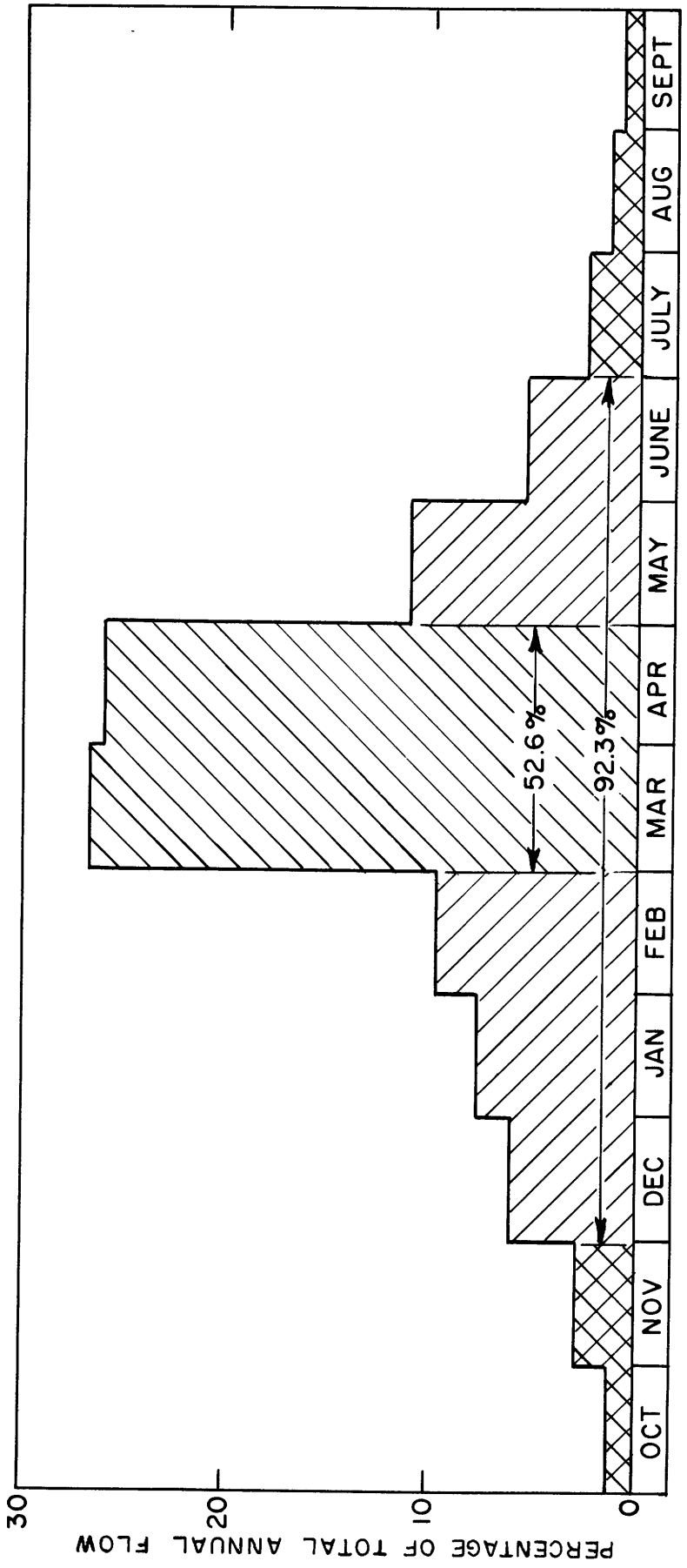

Figure 8.--Percentage of total annual flow contributed each month of the year; based on records of Canaseraga Creek near Dansville, Fivemile Creek near Kanona, and Flint Creek at Phelps.

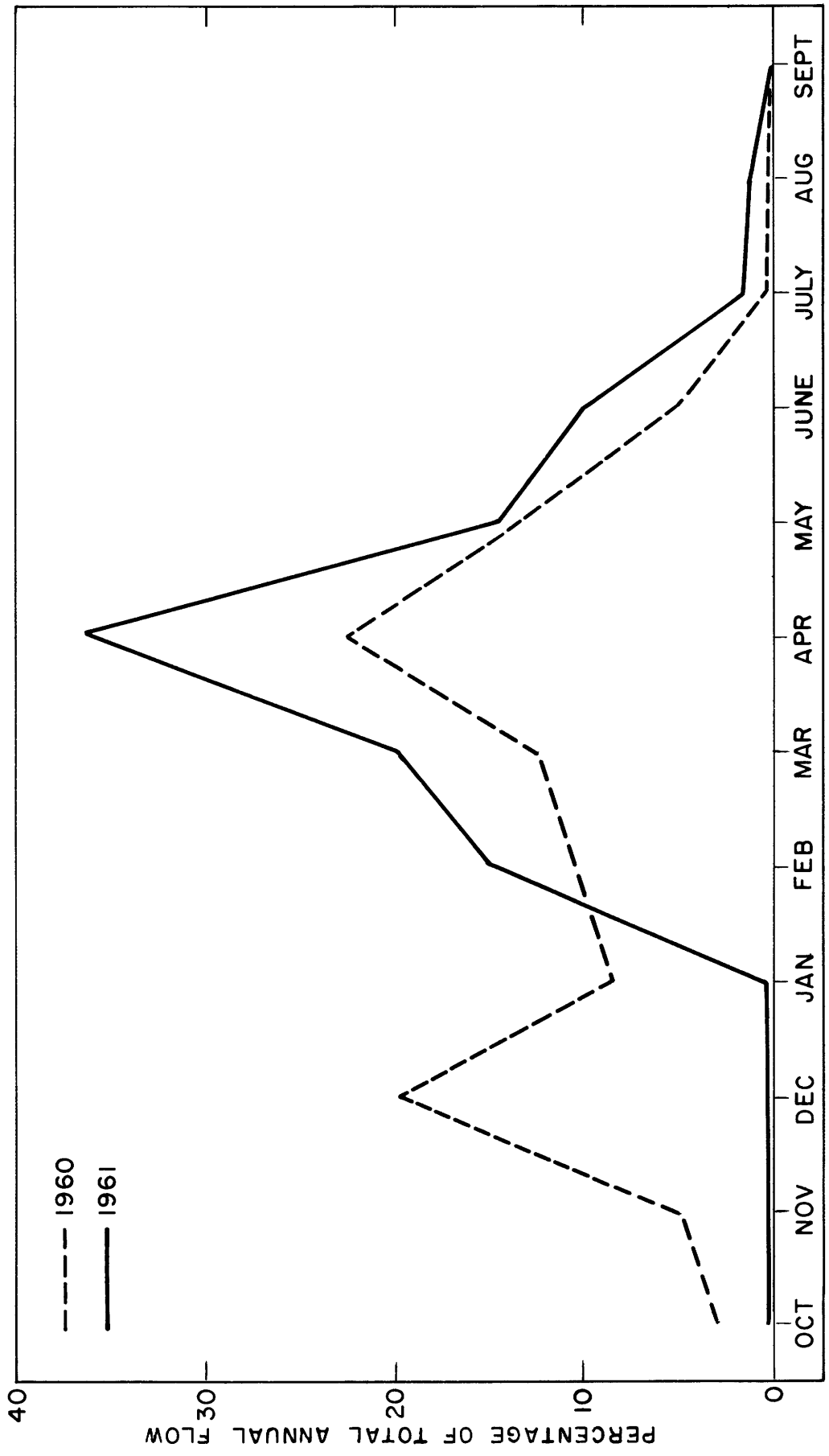

Figure 9.--Percentage of total annual flow of Flint Creek at Phelps contributed each month during the 1960 and 1961 water years.

controlled by areal differences in precipitation, evapotranspiration, geology, and topography. In order for a basin, or even a part of a basin, to have an equal yield for each unit of area, a static relationship between these variables would be necessary. Although such a relationship is virtually impossible in even the smallest of basins, it was possible to divide the Flint Creek basin above Potter into four water-yield subareas (fig. 4) each of which has a nearly consistent relationship between the four variables listed above.

The relationship between the amounts of water produced by the different water-yield subareas of the basin varies with the discharge. To study this relationship a duration curve representing discharge per square mile was developed for each subarea of the basin. These curves were developed by subtracting the streamflow entering a subarea from that leaving the subarea and dividing the resultant by the drainage area of that particular subarea for several duration points. The curves for the subareas 1, 2, 3, and 4 are shown in figure 10. Using the flows at 0.5, 60, and 95-percent duration as examples of high, medium, and low flow, respectively, the relative water yields of the subareas (the most flow per square mile) were determined for each flow condition. Figure 11 shows the results of these determinations.

As figure 11 shows, between the flows representing the 0.5 and the 60-percent duration, the pattern of relative water yield among the subareas completely reverses. This changing relationship is caused mainly by the differences in geology and topography which affect the relative amounts of precipitation that infiltrate the ground and that flow on the land surface directly to streams. Because the low flow is derived largely from ground water (p. 9), both the amount and duration of low flow are directly related to the relative amount of infiltration and, therefore, to the geologic and topographic controls. The sharp downward trend below the 60-percent duration point in the flow duration curves in figure 10 for subareas 3 and 4 occurs because of a relatively rapid depletion of ground-water storage. In those subareas, the amount of ground water that can discharge into the stream channels during periods of low flow is considerably less, per square mile of drainage area, than in subareas 1 and 2. Therefore, when the streamflow is equal to or less than that at the 95-percent duration, the ground-water discharge in subareas 3 and 4 is less than the evapotranspiration losses.

By multiplying the flow per square mile produced in each water-yield subarea and adding the yields of each subarea together in a downstream direction, the total quantity of water available at any point on Flint Creek at any percentage value of duration may be determined. Examples are shown graphically in figure 12. It should be noted that with streamflow less than that at the 95-percent duration, evapotranspiration losses cause the total quantity of water to decrease downstream from subarea 2.

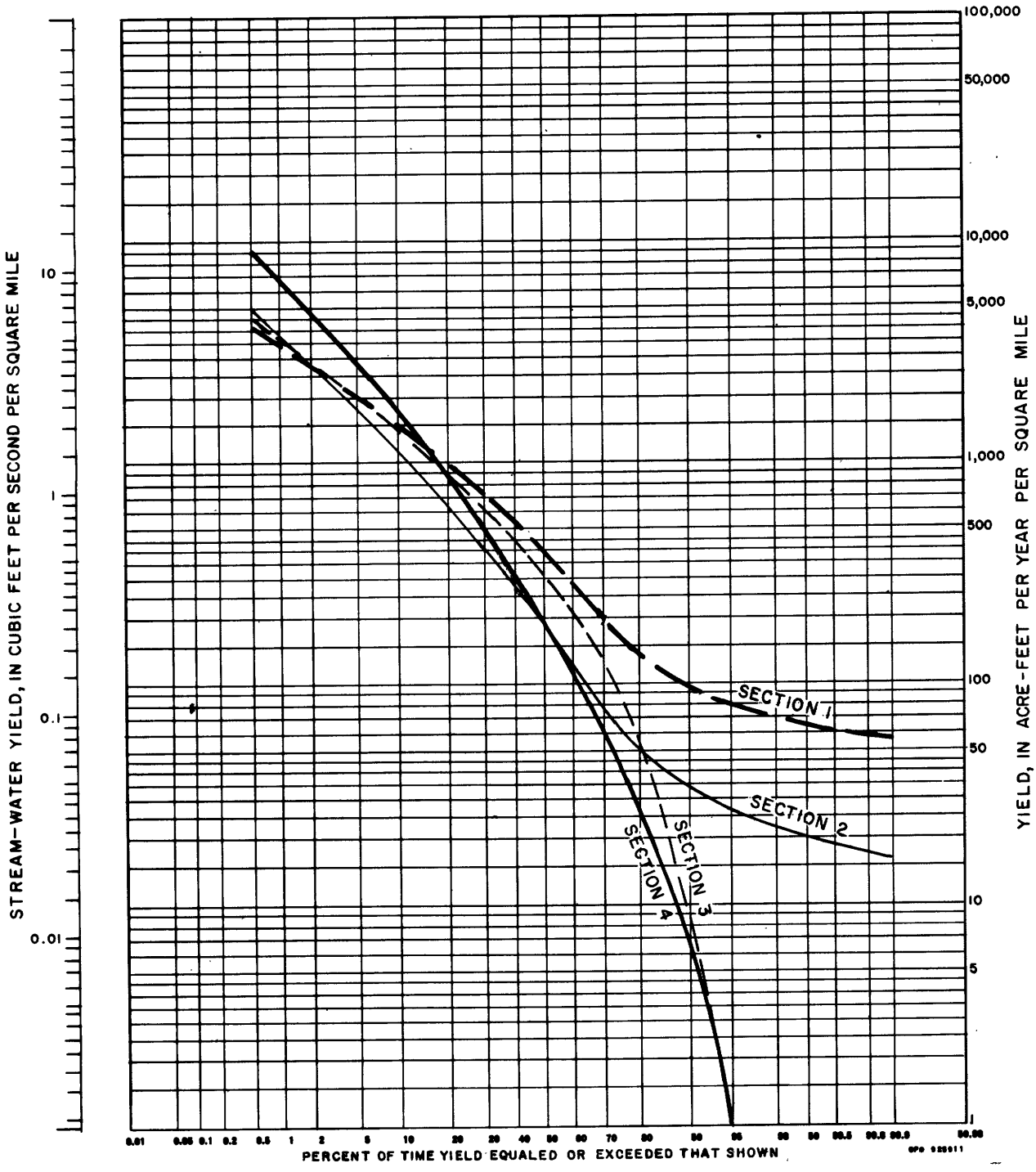

Figure 10.--Duration curves of daily flow, subareas 1, 2, 3, and 4.

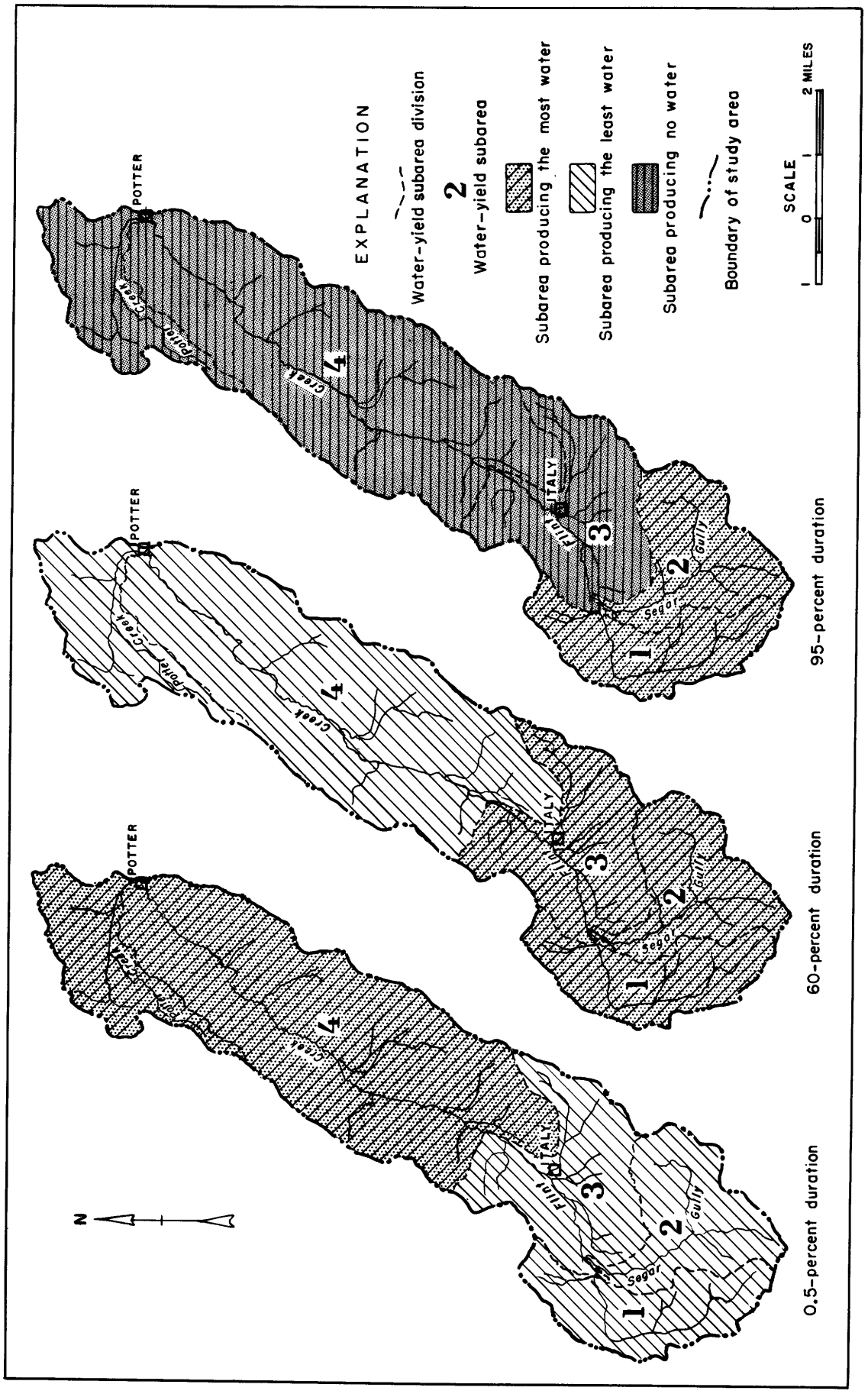

Figure 11.--Relative stream-water yield in subareas at three levels of flow duration.

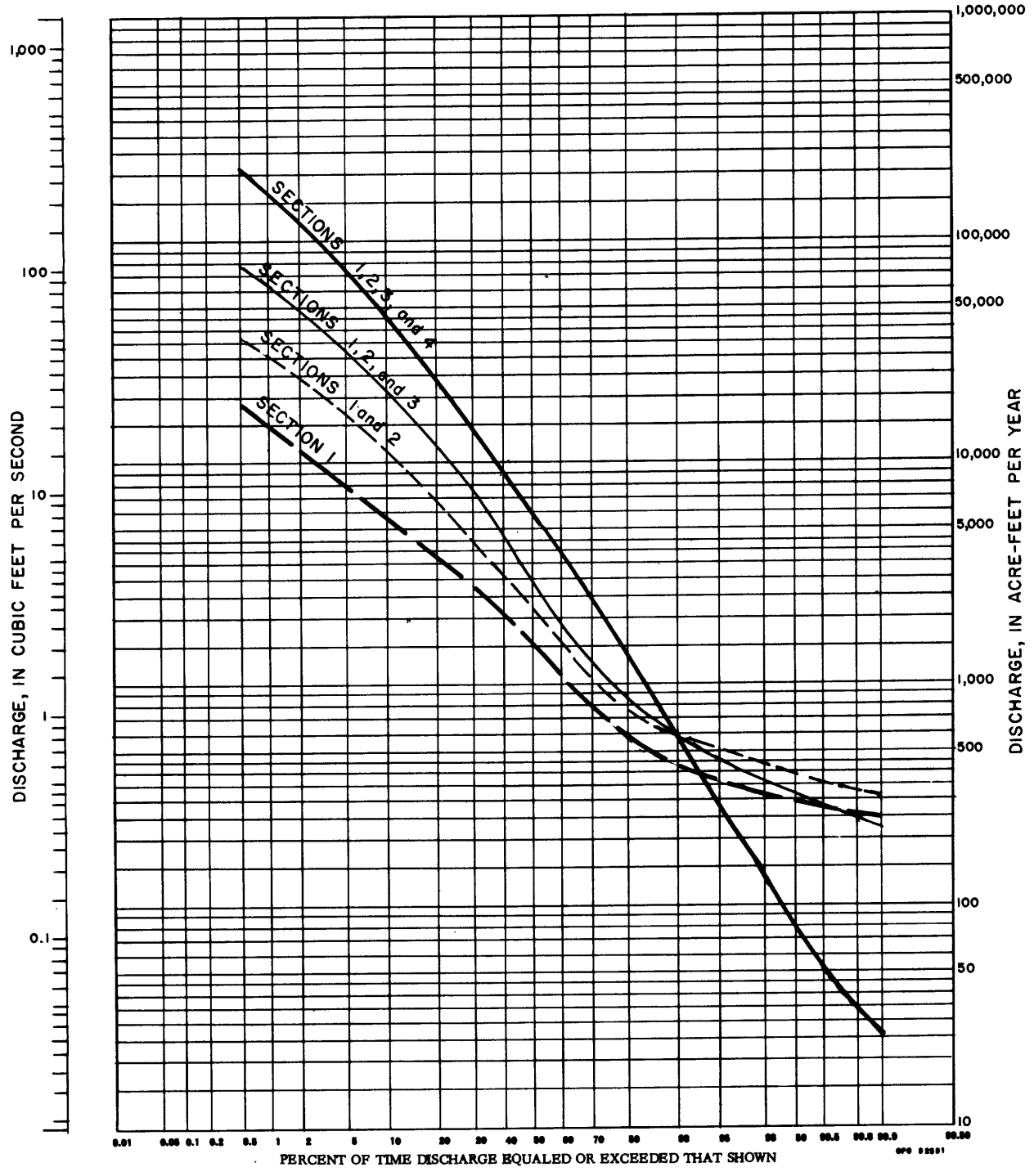

Figure 12.--Quantity of water contributed by each subarea in upper Flint Creek basin at any percentage duration.

EFFECTS OF EVAPOTRANSPIRATION

"Evapotranspiration" is the term for the combined losses of water returned to the atmosphere through evaporation from water and land surfaces and transpiration by vegetation. Evapotranspiration losses in the upper Flint Creek basin occur principally in two ways: (1) transpiration by phreatophytes directly from the ground water, and (2) evapotranspiration of intercepted water in the unsaturated zone above the ground water, including plant surfaces. The small amount of open-water surface in the basin make evaporation losses from these open bodies of water negligible. Phreatophytes -- plants that obtain their water supply directly from the zone of saturation -- are confined to the borders of streams except in areas where the water table is very close to land surface, such as swamps.

Evapotranspiration by interception occurs when some or all of the rainfall that falls is evapotranspired directly back into the atmosphere before it reaches the water table. Interception is the major form of evapotranspiration in the upper Flint Creek basin because the area affected by this process is large compared to the area containing phreatophytes.

However, the reduction of streamflow from station 4 to station 11 (fig. 4), which occurs at flows less than those at the 95-percent duration point, is caused largely by evapotranspiration by phreatophytes. To investigate the nature of this loss a continuous record of discharge was collected at station 4 for a short period of time. This record showed a rather large diurnal fluctuation due to evapotranspiration losses. Figure 13 shows a reproduction of the actual daily-discharge hydrograph and also a curve representing the estimated daily-discharge hydrograph if all evapotranspiration were eliminated. The volume of water between these two curves is considered to be the water lost by evapotranspiration. Figure 13 also shows the cumulative water loss from the stream due to evapotranspiration.

The average annual amount of water lost from the upper Flint Creek basin by evapotranspiration was calculated indirectly by using equation 3 in the earlier section entitled Hydrologic Cycle. This equation can be rewritten:

$$\text{Evapotranspiration} = \text{Precipitation} - (\text{Surface outflow} + \text{Subsurface outflow}). \quad (4)$$

From what is known about the geology of the area there seems to be no continuous aquifer of high permeability that could transmit substantial amounts of water out of the study area underground. Therefore, it is concluded that the subsurface outflow is a very small percentage of the water available and is negligible. Using the above assumption, equation 4 can now be written:

$$\text{Evapotranspiration} = \text{Precipitation} - \text{Surface outflow}. \quad (5)$$

Precipitation was determined from long-term U.S. Weather Bureau stations located near the upper Flint Creek basin (fig. 1) by three independent methods which were (1) arithmetic average, (2) Thiessen

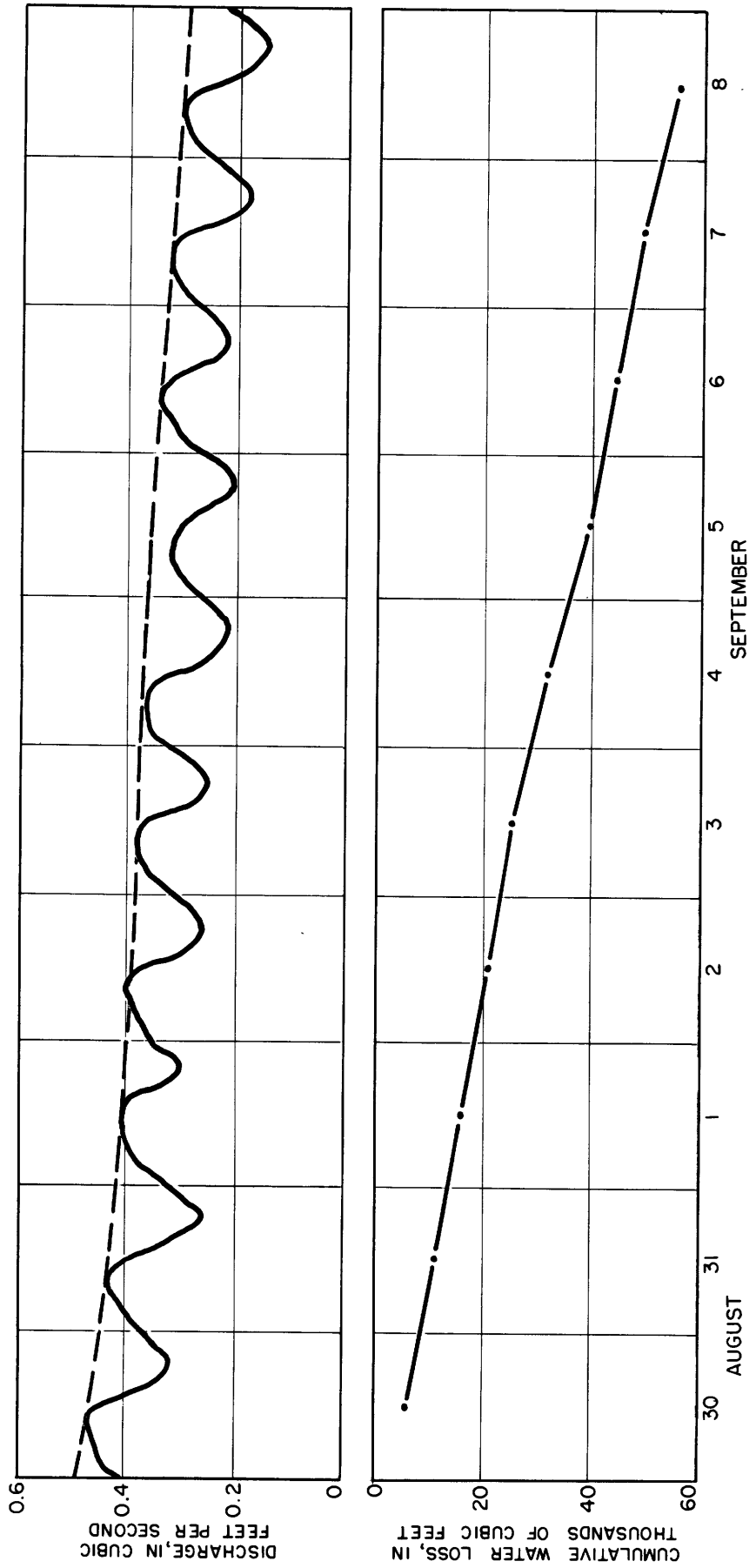

Figure 13.--Water lost from Flint Creek upstream from station 4 by evapotranspiration.

polygons, and (3) isohyetal map. An average of the result of these three methods gave a mean annual precipitation of 35.0 inches or about 58,000 acre-feet.

Average surface outflow, as determined in a preceding part of this report, is equal to 18,500 acre-feet per year. Therefore:

Evapotranspiration = 58,000 - 18,500 = 39,500 acre-feet per year.

This amount is equivalent to 68 percent of the total water available and from the above discussion, it indicates that evapotranspiration is actually the dominant "outflow" factor in the hydrologic cycle of the upper Flint Creek basin.

HYDROLOGY OF THE PROPOSED RESERVOIR

As noted in the introduction to this report, one of the principal objectives of this study was to provide information needed by the New York State Conservation Department in its evaluation of a proposed reservoir to be built near Potter.

The proposed reservoir is to be created by a dam located about 1 mile south of Potter (fig. 4). The drainage area above the dam is 26.6 square miles. At its lowest stage the reservoir will cover 600 acres and have a storage capacity of 5,000 acre-feet, which will form a permanent lake to be used for recreation. When completely filled, it will cover 1,200 acres and hold 25,000 acre-feet of water. The top 5,000 acre-feet, however, will be reserved for flood control. The remaining 15,000 acre-feet is proposed for use as indicated in table 2.

Table 2.--List of uses and amount of water planned for each use for the proposed Flint Creek reservoir

Proposed use of water	Amount of water allotted (acre-feet)
Flood control	5,000
Irrigation	10,000
Industrial water supply	1,000
Supplementation of streamflow	4,000
Recreation	5,000

The proposed damsite is located in an area of sand and gravel deposits with relatively high permeability (fig. 3). Depending on the thickness of the deposits, this geologic situation could result in the need for considerable excavation and implacement of impermeable fill during construction of the dam. However, it should be noted that the sand and gravel deposit appears to be absent about 1,000 feet upstream from the proposed site.

STORAGE FOR LOW-FLOW AUGMENTATION

Because the proposed pattern of withdrawal from the reservoir is not known at the present time, a general draft-stage relationship for Flint Creek at Potter (sta. 11) was developed. This relationship, which is shown in figure 14, was obtained by combining the needed seasonal and carryover storage developed by statistical analysis of streamflow records at station 11 and at stations on surrounding streams.

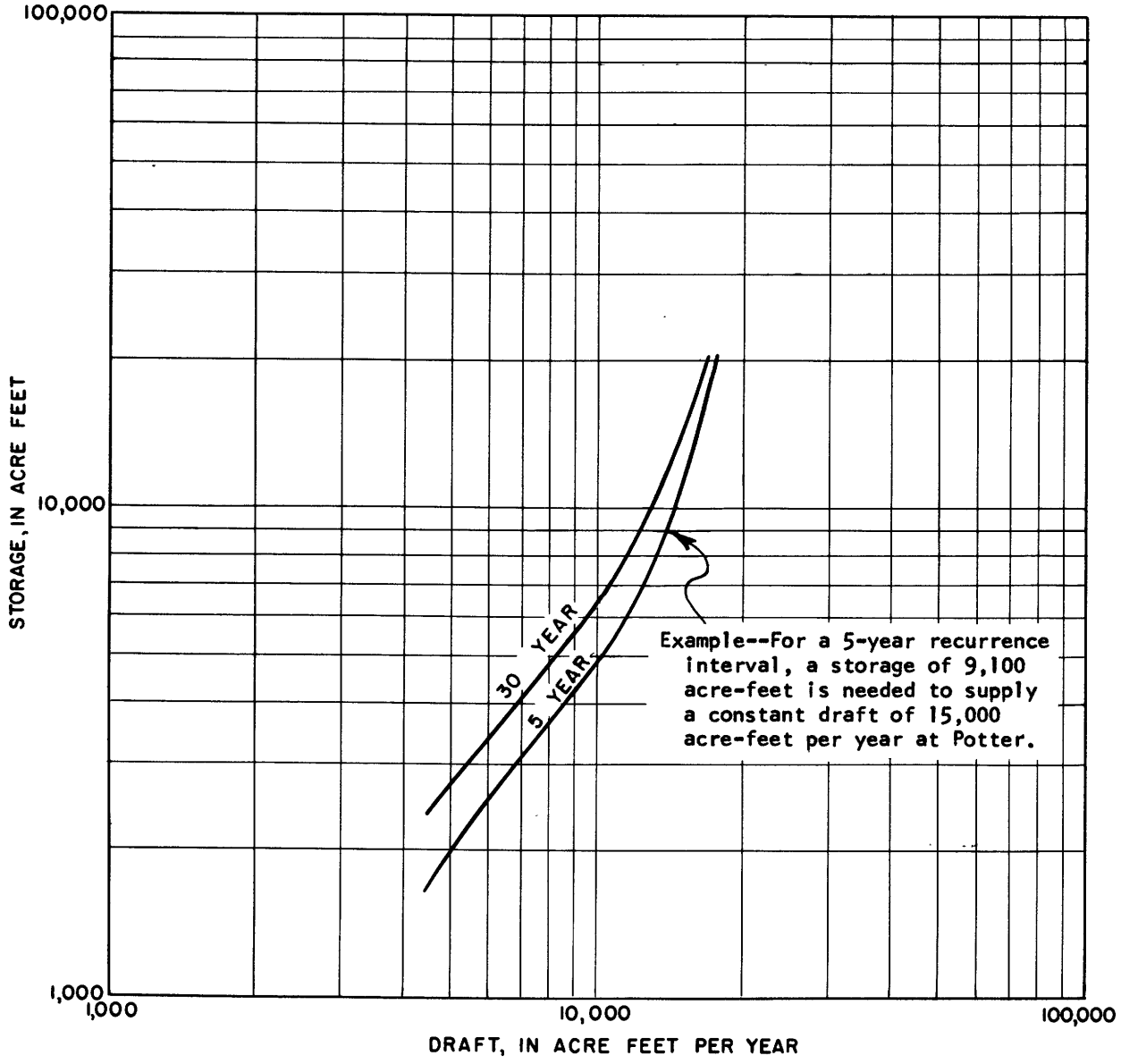
100,000
10,000
1,000
STORAGE, IN ACRE FEET
1,000
10,000
100,000
DRAFT, IN ACRE FEET PER YEAR
30 YEAR
5 YEAR
Example--For a 5-year recurrence interval, a storage of 9,100 acre-feet is needed to supply a constant draft of 15,000 acre-feet per year at Potter.

Figure 14.--Draft-storage relationship curve for Flint Creek at Potter, (station 11).

Seasonal storage was calculated with the use of probability curves of recurrent flow of different time periods on several nearby streams using a method described by H. C. Riggs, U.S. Geological Survey (written communication, 1966).

Carryover storage was obtained under the direction of C. H. Hardison, U.S. Geological Survey (written communication, 1966), using a method based on the log-normal distribution of annual flows of Flint Creek at station 11.

FLOOD STORAGE

The amount of storage required to reduce flood discharge to an acceptable level of flow depends as much on the duration of high rates of inflow as on the magnitude of the flows. This storage also depends on the storm-runoff frequency for which the reservoir is designed. A reservoir designed to regulate the runoff from a 50-year storm, for example, needs to be larger than one for a 20-year storm. For storms larger than those of the designed frequency, the reservoir will fill and discharge through an emergency spillway and, thus, be unable to keep the outflow to the designed rate.

Design of a flood-storage reservoir on a frequency basis requires knowledge of the magnitude and frequency of inflow volumes to be expected for durations ranging from a few days to several months. At reservoir sites near a long-term stream-gaging station, the required information can be obtained by analysis of annual high flows for selected numbers of consecutive days such as are given by routine processing on an electronic computer; however, at other sites distant from a long-term gaging station, more involved hydrologic interpretation is required. The proposed damsite falls in the latter class because there is less than 1 year of record at the stream-gaging station at the site and because the streamflow record on Flint Creek downstream at Phelps is not only rather short (5-year) but also is not very representative of flood flows in the upper part of the basin.

For ungaged sites and for sites such as that near Potter where the streamflow record is short, G. A. Kirkpatrick (oral communications, 1965) proposes that the flood-volume frequency characteristics be obtained by regionalizing the statistical parameters needed to define the distribution curves of high flow for selected periods of consecutive days. Such an analysis for the Potter Creek site was made under his direction and the resulting storage-draft frequency curves are shown in figure 15.

The records for 8 gaging stations within 60 miles of the damsite were used in the regionalization analysis. The statistical parameters for the damsite, however, (mean logarithm, standard deviation of the logarithms, and skew coefficient of the logarithms) for each period of consecutive days were based largely on the mean logarithms at the two stations, Karr Valley Creek at Almond, N. Y., 1938-60, and Little Tonawanda Creek at Linden, N. Y., 1938-59, because the size of the drainage area at these two gaging stations is about the same as at the damsite.

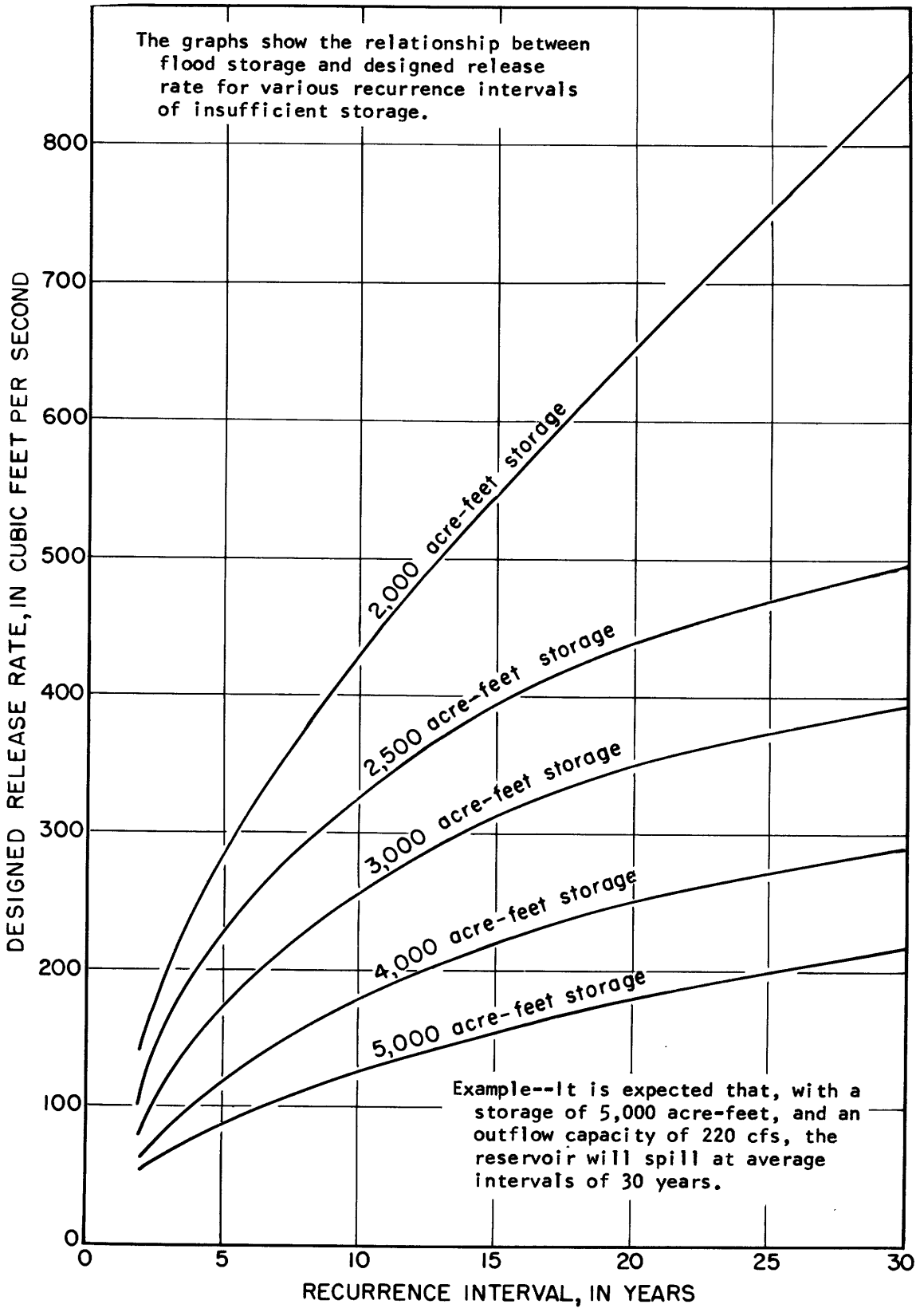

Figure 15.--Flood-detention frequency curves of Flint Creek at the proposed damsite near Potter.

In this method of regionalization, flood-runoff characteristics are related to size of drainage area rather than to average annual runoff. At high levels of regulation, however, the critical period for storage becomes longer and the volume of runoff to be retained tends to vary with the amount of average annual runoff. For short critical periods, the relation between flood runoff and average annual runoff diminishes in importance. Because the critical periods for the curves shown in figure 15 are rather short (60 days to 10 days for the 5,000 acre-foot curve and from 10 days to 3 days for the 2,500 acre-foot curve, with the shorter critical periods being associated with the longer recurrence intervals), no adjustment for differences in average annual runoff is deemed necessary even though the average annual runoff at the damsite is estimated to be about 12 inches as compared to an average of about 16 inches for the stations used in the analysis.

SUMMARY AND CONCLUSIONS

The Flint Creek basin above Potter, New York, is a long, narrow, glaciated valley covering a drainage area of 31 square miles. Its physical features are very similar to the valleys occupied by the surrounding Finger Lakes. The geology of the area consists of a "bedrock" sequence of interbedded shale, siltstone, and sandstone overlain by glacial deposits. Most of these unconsolidated deposits have a low permeability and allow very little infiltration.

Due to evapotranspiration losses, only about 32 percent of the precipitation runs off as streamflow and is available for surface-water storage. In an average year this runoff is equal to about 18,500 acre-feet per year at the gaging station at Potter. At average intervals of once every 30 years the following discharges are expected at Potter:

Lowest annual mean - equal to or lower than 10,000 acre-feet per year.

Highest annual mean - equal to or in excess of 30,000 acre-feet per year.

In an average year more than 40 percent of the total annual flow occurs during the months of March and April, and over 90 percent of the total annual flow occurs between December and the following June.

During periods of low flow (90- to 99.9-percent duration), the discharge of Flint Creek is controlled by the yield of water from the ice-contact deposits at the southern end of the valley and also by the effect evapotranspiration has on this yield as the stream flows north to Potter.

If a recurrence interval of 30 years is considered, the proposed reservoir would require (1) a minimum storage of 14,500 acre-feet to supply a constant draft of 15,000 acre-feet per year and (2) a flood storage of 5,000 acre-feet to limit reservoir outflow to approximately 200 cubic feet per second. A highly variable withdrawal, however, could require a much higher storage capacity to supply an annual draft of 15,000 acre-feet.

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Searcy, J. K., 1959, Flow-duration curves: U.S. Geol. Survey Water-Supply Paper 1542-A, 33 p.

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Table 3.--Records of selected wells in the upper Flint Creek basin

Well number	Owner	Date completed	Altitude above sea level (feet)	Type of well	Depth of well (feet)	Depth of casing (feet)	Diameter (inches)	Depth to bedrock (feet)	Water-bearing material	Water level Below land surface datum (feet)	Water level Date	Yield (gallons per minute)	Use
236-717-1	J. Elwell	--	1120	Dug	12	12	36	--	Sand and gravel	4.3	3/19/65	--	Domestic
-2	do.	1964	1120	Drilled	27	27	6	--	do.	7.8 7.6	3/19/65 3/31/65	r3	Do.
-3	A. Williams	1959	1120	Drilled	r87	r87	r6	--	do.	r6	7/ /59	r36	Do.
-4	J. Cares	1959	1120	Drilled	r109	r109	r6	--	do.	r3	7/ /59	r36	Do.
-5	B. Davis	1960	1120	Drilled	r22	r22	r6	--	do.	r16	9/ /60	r3	Do.
-6	T. McMichael	1961	1120	Drilled	r46	r46	r6	--	do.	r34	10/ /61	r5	Do.
-7	J. Hicks	1961	1120	Drilled	r48	r48	r6	--	do.	r36	10/ /61	r5	Do.
236-719-1	W. Eveland	1959	1280	Drilled	r27	r20	r6	r18	Bedrock	r10	--	--	Do.
241-712-1	J. Gule	1948	1060	Drilled	r50	r45	r6	r45	do.	--	--	r5	Agriculture & Domestic

r - reported.

Table 4.--Location and drainage area of stream-gaging stations in the upper Flint Creek basin

Station name	Map no.	U.S.G.S. Station number	Latitude	Longitude	Drainage area (sq mi)
Flint Creek near Daball Corners	1	--	42°34'00"	77°19'47"	0.3 e/
Flint Creek near Prattsburg	2	2351.0	42°34'25"	77°20'09"	.76
Flint Creek near Ingleside	3	--	42°35'14"	77°20'36"	1.71
Flint Creek near Italy	4	2351.1	42°36'04"	77°19'27"	3.70
Segar Gully near Italy Hill	5	--	42°34'45"	77°18'20"	2.2 e/
Segar Gully near Italy	6	2351.2	42°36'06"	77°19'11"	4.03
Flint Creek near Italy Hill	7	2351.3	42°37'31"	77°16'54"	13.2
Flint Creek near Middlesex	8	2351.4	42°39'05"	77°16'15"	17.9
Flint Creek near Potter	9	--	42°41'09"	77°13'46"	25.2
Unnamed Tributary at Potter	10	--	42°42'15"	77°12'34"	3.22
Flint Creek at Potter	11	2351.5	42°42'09"	77°12'25"	31.0
Nettle Valley Creek at Friend	12	--	42°39'51"	77°11'06"	2.5 e/
Nettle Valley Creek Tributary at Friend	13	--	42°39'52"	77°11'30"	1.0 e/
Nettle Valley Creek Tributary Number 2 at Friend	14	--	42°40'07'	77°11'46"	1.0 e/
Nettle Valley Creek near Friend	15	--	42°40'37"	77°11'11"	5.5 e/
Nettle Valley Creek near Potter	16	2351.6	42°41'33"	77°11'21"	6.98

e/ Estimated.

Table 5.--Discharge measurements made at stream-gaging stations in the upper Flint Creek basin. (all measurements listed below were made during periods of base flow and by current meter, except as otherwise noted. A zero discharge listing indicates there was no visible flow or the channel was dry.)

Station number	Station name	Date	Time	Discharge (cfs)
--	Flint Creek near Daball Corners	8- 4-64	--	0.05 a/
		9-14-64		0
2351.0	Flint Creek near Prattsburg	3-23-64	1500	.97 b/
		3-25-64	1410	26.8 b/
		4-23-64	1325	2.08 b/
		5- 8-64	1150	.34
		5-28-64	1010	.11
		6-22-64	1445	.04
		8- 5-64	0940	0
		8- 6-64	--	0
		9-14-64	1500	0
		9-28-64	--	0
		10- 1-64	1015	0
		10- 2-64	1045	0
		10-12-64	1300	0
		11- 9-64	1245	0
--	Flint Creek near Ingleside	3-23-64	1520	2.73 b/
		9-14-64	1600	.08
		9-15-64	0945	.10
2351.1	Flint Creek near Italy	10- 2-63	0830	.48
		3-23-64	1540	6.02 b/
		3-25-64	1440	49.2 b/
		4-23-64	1450	10.1 b/
		5- 8-64	1245	3.50
		5-28-64	1110	2.48
		6-22-64	1520	1.46
		8- 5-64	0950	.59 c/
		8- 6-64	0920	.58 c/
		8-28-64	1005	.52 c/
		9-14-64	1600	.26 c/
		9-15-64	0930	.35 c/
		9-28-64	1540	.41 c/
		9-29-64	1145	.44 c/

a/ Field estimate.
b/ Not base flow.
c/ Measured with Parshall flume.

Table 5.--Discharge measurements at stream-gaging stations (Continued)

Station number	Station name	Date	Time	Discharge (cfs)
2351.1	Flint Creek near Italy (continued)	10- 1-64	1045	.44 c/
		10- 2-64	1000	.41 c/
		10-12-64	1350	.46 c/
		11- 9-64	1300	.51 c/
		12- 8-64	1045	.60 b,c/
--	Segar Gully near Italy Hill	9-14-64	1540	.06
2351.2	Segar Gully near Italy	3-25-64	1500	98.5 b/
		4-23-64	1150	12.9 b/
		5- 8-64	1230	2.53
		5-28-64	1220	.97
		6-22-64	1600	.85
		8- 5-64	0955	.15 c/
		8- 6-64	0940	.13 c/
		8-28-64	1015	.15 c/
		9-14-64	1610	.07 c/
		9-15-64	1015	.10 c/
		9-28-64	1630	.14 c/
		9-29-64	1130	.12 c/
		10- 1-64	1115	.12 c/
		10- 2-64	1020	.12 c/
		10-12-64	1400	.13 c/
		11- 9-64	1330	.19 c/
		12- 8-64	0940	.19 b,c/
2351.3	Flint Creek near Italy Hill	10- 2-63	0900	.59
		3-23-64	1610	23.7 b/
		4-23-64	1620	37.7 b/
		5- 8-64	1030	11.7
		5-28-64	1440	6.26
		6-22-64	1630	3.80
		8- 5-64	1030	.69
		9-14-64	1700	.21
		9-29-64	1110	.23
		10- 1-64	1235	.30
2351.4	Flint Creek near Middlesex	3-23-64	1640	32.5 b/
		3-25-64	1550	242 b/
		4-24-64	1030	51.4 b/
		5- 8-64	1025	12.8
		5-28-64	1600	7.72
		6-22-64	1705	4.22

b/ Not base flow.
c/ Measured with Parshall flume.

Table 5.--Discharge measurements at stream-gaging stations (Continued)

Station number	Station name	Date	Time	Discharge (cfs)
2351.4	Flint Creek near Middlesex (continued)	8- 6-64	1045	.53
		9-29-64	--	.14
		10- 1-64	1440	.19
		12- 8-64	1430	1.81 b/
--	Flint Creek near Potter	3-24-64	1000	41.4 b/
		3-25-64	1615	118 b/
--	Potter Creek at Potter	3-26-64	1520	19.2 b/
		4-23-64	1050	3.66 b/
		4-24-64	1150	1.91 b/
		5- 8-64	--	0
		12- 8-64	--	0
2351.5	Flint Creek at Potter	9-24-63	0940	.27
		10- 2-63	0925	.35
		2-28-64	0940	7.05
		3- 5-64	1455	675 b/
		3- 6-64	0910	465 b/
		3-23-64	1315	57.4 b/
		3-25-64	1315	119 b/
		3-25-64	1700	137 b/
		3-26-64	1045	260 b/
		4-24-64	1110	95.5 b/
		5- 8-64	0915	19.8
		5-27-64	1705	14.3
		6-23-64	1010	5.44
		7-17-64	1525	1.10
		8- 5-64	1240	.70
		8- 6-64	1135	.35
		9-15-64	1400	.05
		9-29-64	0920	.02 c/
		10- 1-64	1630	.03 c/
		12- 8-64	1540	1.47 b/
--	Nettle Valley Creek at Friend	9-15-64	--	0
--	Nettle Valley Creek Tributary at Friend	9-15-64	--	0
--	Nettle Valley Creek Tributary Number 2 at Friend	9-15-64	--	0

b/ Not base flow.
c/ Measured with Parshall flume.

Table 5.--Discharge measurements at stream-gaging stations (Continued)

Station number	Station name	Date	Time	Discharge (cfs)
--	Nettle Valley Creek near Friend	9-15-64	1615	.18
2351.6	Nettle Valley Creek near Potter	10- 2-63	--	.35
		3- 6-64	0920	30.0 b/
		3-24-64	0910	11.6 b/
		3-26-64	1430	65.6 b/
		5-27-64	1830	1.98
		7-21-64	1105	.48
		8-28-64	0925	.51
		9-15-64	1520	.33
		10- 2-64	1130	.25
		10-12-64	1300	.29

b/ Not base flow.

Table 6.--Daily discharge during 1964 in cubic feet per second, at gaging stations in the upper Flint Creek basin

Date	2351.1 Flint Creek near Italy				
	July	Aug.	Sept.	Oct.	Nov.
1	--	0.44	0.37	a/0.41	0.49
2	--	.49	.35	a/ .41	.49
3	--	.76	.35	.44	.46
4	--	.56	.30	.35	.44
5	--	a/.56	.28	.37	.49
6	--	a/.49	.28	.37	.67
7	--	.39	.26	b/	.51
8	--	.39	.24	b/	.54
9	--	.39	.26	b/	a/.51
10	--	.37	.26	b/	.49
11	--	.37	.26	b/	.49
12	--	.59	.26	a,b/	.49
13	--	.44	.26	.41	.46
14	--	.51	a/.26	.41	.44
15	--	.51	a/.30	.39	.44
16	--	.39	.26	.39	.56
17	--	.37	.26	.39	.59
18	--	.41	.30	.41	.56
19	0.64	.51	.32	.62	.64
20	.59	.54	.39	.51	.87
21	.59	.90	.35	.51	.70
22	.59	1.16	.30	.54	--
23	.54	.70	.30	.56	--
24	.59	.51	.30	.51	--
25	.56	.46	.37	.49	--
26	.54	1.06	.37	.49	--
27	.46	.56	.37	.46	--
28	.41	a/.44	a/.44	.44	--
29	.59	.41	a/.44	.59	--
30	.54	.41	.44	.59	--
31	.46	.35	--	.51	--

Date	2351.5 Flint Creek at Potter									
	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	8.4	57	45	10	2.2	0.68	0.34	a/0.03	0.92	2.2
2	9.3	51	40	12	2.0	.68	.23	.03	1.1	1.7
3	13	59	35	10	3.5	.76	.23	.18	1.1	1.4
4	30	70	31	11	4.9	.76	.28	.18	1.1	2.0
5	a/506	53	28	9.0	3.3	.76	.34	.23	1.1	3.1
6	a/466	52	25	8.1	2.6	.44	a/.28	.23	1.2	2.8
7	185	74	22	11	2.0	.34	.28	.28	1.2	2.2
8	130	177	a/22	12	1.4	.34	.23	.28	1.2	a/1.8
9	121	151	22	10	1.6	.28	.23	.28	1.2	2.2
10	123	90	20	7.8	1.6	.34	.23	.28	1.3	1.7
11	118	70	18	6.7	1.4	.28	.18	.39	1.2	2.2
12	115	58	17	5.9	1.6	.28	.12	.44	1.1	4.1
13	91	53	17	5.9	2.0	.18	.05	.34	1.1	5.9
14	83	49	40	5.7	2.4	.18	.05	.34	1.0	3.1
15	267	46	62	10	1.4	.28	a/.03	.28	.84	4.7
16	258	39	49	14	1.2	.44	.03	.40	1.2	2.9
17	155	34	36	8.7	a/1.1	.28	.05	.34	1.3	2.8
18	114	31	30	7.0	.92	.18	.03	.34	1.2	2.6
19	86	37	26	5.9	1.0	.12	.03	.49	1.2	2.0
20	74	61	34	5.4	.68	.18	.03	.60	1.7	1.8
21	70	127	28	5.4	1.3	.49	.03	.49	1.6	2.0
22	65	146	23	7.0	1.2	1.2	.03	.55	1.7	2.2
23	a/58	143	19	a/5.2	1.0	1.2	.02	.55	1.8	2.3
24	55	a/94	17	4.3	3.7	1.2	.02	.60	1.8	3.3
25	a/101	66	20	3.9	5.7	.84	.02	.68	2.3	4.5
26	a/234	54	16	3.7	2.4	1.0	.02	.84	3.9	6.5
27	227	47	a/14	3.1	1.4	.84	.02	.84	3.7	6.5
28	116	43	12	2.6	1.1	1.1	.03	.68	2.8	5.2
29	116	41	12	2.9	.92	.60	a/.03	.92	2.4	3.9
30	94	44	11	2.4	.84	.44	.03	1.1	2.2	3.9
31	66	--	9.9	--	.76	.39	--	.92	--	4.5

a/ Discharge measurement made on this day.
b/ No record.

Table 6.--Daily discharge during 1964 in cubic feet per second, at gaging stations in the upper Flint Creek basin (Continued)

Date	2351.2 Segar Gully near Italy					2351.6 Nettle Valley Creek near Potter								
	July	Aug.	Sept.	Oct.	Nov.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
1	--	0.10	b/	a/0.12	0.17	--	8.4	8.6	2.0	0.7	b/	0.3	0.4	0.9
2	--	.11	b/	a/ .12	.17	--	7.9	8.6	2.1	.6	b/	.3	a/.4	.9
3	--	.23	b/	.15	.17	--	12	8.1	2.2	.9	b/	.3	.4	.9
4	--	.17	b/	.12	.17	--	10	7.9	2.2	.9	b/	.3	.5	.9
5	--	a/.14	b/	.11	.20	--	8.1	6.9	2.2	.8	b/	.3	.5	.9
6	--	a/.13	b/	.12	.27	a/	11	5.9	2.2	.7	0.5	.3	.5	.8
7	--	.10	b/	.13	.20	19	16	4.7	2.2	.7	.5	.3	.5	.8
8	--	.14	b/	.12	.19	17	22	4.2	2.2	.6	.5	.3	.6	.9
9	--	.11	b/	.12	a/.19	24	13	4.4	2.0	.6	.4	.3	.6	.9
10	--	.10	b/	.13	.19	15	9.8	4.2	1.8	.6	.4	.3	.6	.9
11	--	.10	b/	.13	.19	15	8.4	3.8	1.8	.5	.4	.3	.7	.9
12	--	.21	b/	a/.13	.19	15	7.3	3.7	1.7	.5	.4	.3	a/.6	.9
13	--	.14	b/	.13	.18	14	6.9	3.7	1.6	1.0	.4	.3	.6	.9
14	--	.16	a,b/	.13	.18	18	6.9	6.5	1.5	.8	.4	.2	.6	.9
15	--	b/	a,b/	.12	.17	30	6.5	11	1.7	.7	.4	a/.2	.6	.9
16	--	b/	0.09	.12	.22	23	5.6	6.1	1.8	.6	.4	.2	.6	.9
17	--	b/	.09	.12	.25	17	5.6	5.0	1.6	.6	.3	.2	.6	.9
18	--	b/	.08	.12	.20	b/	5.7	4.2	1.4	.6	.3	.2	.6	.9
19	0.17	b/	.08	.22	.26	b/	8.1	5.6	1.2	.5	.3	.2	.6	.9
20	.17	b/	.11	.19	.38	b/	19	6.7	1.1	.5	.3	.2	.7	.9
21	.16	b/	.10	.17	.27	b/	19	5.2	1.1	a/1.7	.4	.3	.7	--
22	.16	b/	.08	.20	.25	b/	22	4.2	1.5	1.5	.5	.3	.7	--
23	.14	b/	.07	.20	.24	b/	14	3.5	1.3	.9	.5	.3	.8	--
24	.16	b/	.08	.19	.28	a,b/	12	3.2	1.1	.9	.4	.3	.8	--
25	.17	b/	.14	.17	.42	23	11	3.1	1.0	1.4	.4	.3	.8	--
26	.15	b/	.14	.17	.64	a/37	9.1	2.9	1.0	.9	.4	.3	.8	--
27	.13	b/	.14	.17	.36	18	8.1	a/2.5	.9	.7	.4	.3	.7	--
28	.10	a,b/	.14	.16	--	12	8.4	2.1	.9	.7	a/.3	.4	.7	--
29	.19	b/	a/.13	.24	--	17	8.1	2.1	.8	b/	.3	.4	.8	--
30	.15	b/	.12	.25	--	11	8.6	2.0	.7	b/	.3	.4	.8	--
31	.11	b/	--	.19	--	8.4	--	2.0	--	b/	.3	--	.8	--

a/ Discharge measurement made on this day.
b/ No record.

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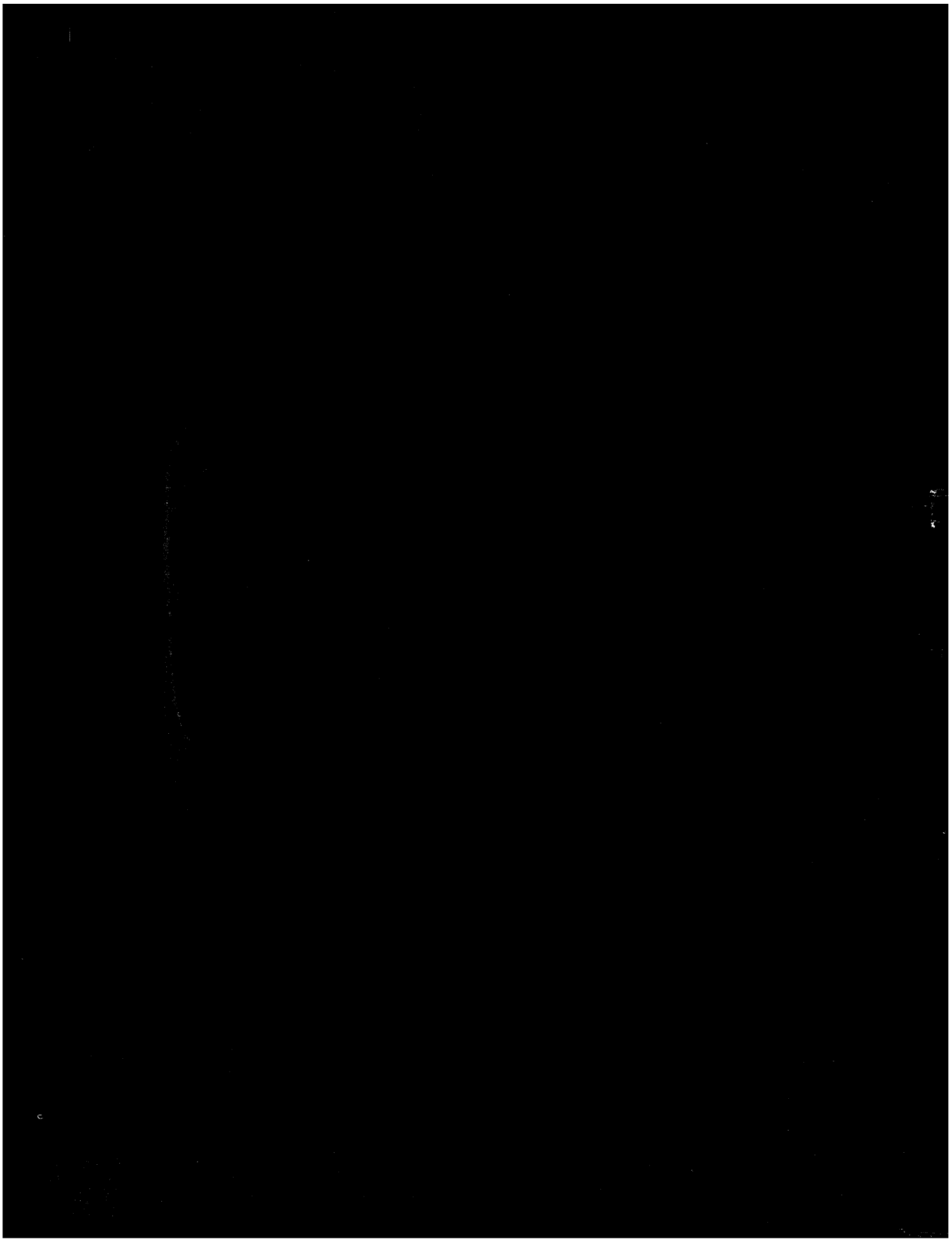
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